Joseph Technology Corporation

TECHNICAL ASSISTANCE TO AID CDBG COMMUNITIES IN THE DEVELOPMENT OF ENERGY SYSTEMS BASED ON DISTRICT HEATING AND COOLING PROJECTS

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Introduction

Miami Justice Center Chilled Water System

Providence DHC

Jordan Commons Model Community

Harrisburg District Heating System

Camden DHC

Conferences

ACKNOWLEDGMENTS

The project was performed under the direction of HUD project managers Messrs. Bernard Manheimer and Bernard McShane.

The contributions made by the above listed participants is very much appreciated.

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SECTION 1

INTRODUCTION

Joseph Technology Corporation, Inc., (JTC) has been selected by the U.S. Department of Housing and Urban Development to provide technical assistance to cities which are developing Community Energy Systems, (CES) which supply district heating and cooling.(DHC).

The scope of work of this project included three major types of assistance:

1) technical assistance to individual CDBG communities,

2) generic technical assistance through training workshops and conferences and

3) evaluation of the technical assistance.

<u>Assistance Category # 1: Technical Assistance to Individual CDBG Communities</u>

Technical assistance was made available to participating CDBG Communities as selected by the HUD Government Technical Representative (GTR). Technical expertise which was made available included marketing, engineering, economic feasibility, financial, and ownership considerations, the tasks generally encountered in the development of community energy systems. Assistance was provided on a periodic basis as determined by the HUD GTR.

For the selected cities the following tasks have been performed:

- verification of CDBG eligibility and performance,
- preview the specific community and the CES/District Heating and Cooling (DHC) opportunity,
- problem identification,
- determination of specific topics requiring assistance including engineering and economic analysis as it applies to heat source, distribution system and potential customers, marketing strategy, sources of financing, ownership options, and environmental issues,
- review of available information pertaining to the selected site,

- site visits to collect information and assess community specific issues,
- assessments as follows: engineering assessments, utilizing available computer software; economic analysis to support engineering; institutional issues which influence the progress of the project; ownership and financing arrangements,
- preparation of recommendations,
- preparation of reports to the community and the HUD GTR,
- following up assistance.

Assistance Categories # 2: Generic Technical Assistance, National Conferences/Regional Workshops

Three National Conferences and two Regional Workshops were organized. Coordination efforts for the conferences and workshops included:

- Agenda and schedule
- Pre-workshop advertising
- Workshop aids (desk guides, workbooks, case studies bulletins).
- Committing speakers
- Hotel arrangements & registration

The conduct of the conferences and workshops included:

- CDBF funding linkage to CES/DHC
- Institutional and legal issues
- Community development/revitalization, integration with CES/DHC
- System development and marketing
- Technical and economic questions
- Environmental impact

Assistance Category # 3: Evaluation of Technical Assistance

This section included the evaluation of Technical Assistance to Individual Cities and preparation of the final report.

This task also included preparation of Quarterly Technical Progress Reports consisting of assessments regarding individual cities and related tasks.

JTC provided to the HUD GTR and Contracting Office a project management system workplan and regular monthly status reports showing actual progress against the workplan. The project management system utilized two reporting forms (the HUD 441.1 Baseline Plan and the HUD 661.1 Progress Report), in addition to a narrative description.

The following report presents the summaries of the outlined activities for different cities.

SECTION 2

MIAMI JUSTICE CENTER CHILLED WATER SYSTEM

2.1 Introduction

The Department of Development and Facilities Management (DDFM) of Metro-Dade County, Florida is developing a central chilled water plant for the Justice Center. This plant can be integrated with a large chilled water system in a neighboring development covering five Miami hospitals (Figure 2-1).

The major task of the HUD cooperative agreement was to develop an underground water supply source to the chilled water plant and compare the condenser water supply provided by a well water system with that provided via cooling towers.

Sub-tasks for this project have included:

A. Determine if well water at this location may be used as a heat sink for refrigeration condensers as well as for diesel engine cooling.
   1. Drill one supply and one discharge well.
   2. Establish the separation necessary for the supply and discharge well to allow formation of a heat sink without cross-contamination.

B. Test, study and review water sample analysis and make metallurgical recommendations for chillers, pumps and heat exchangers.

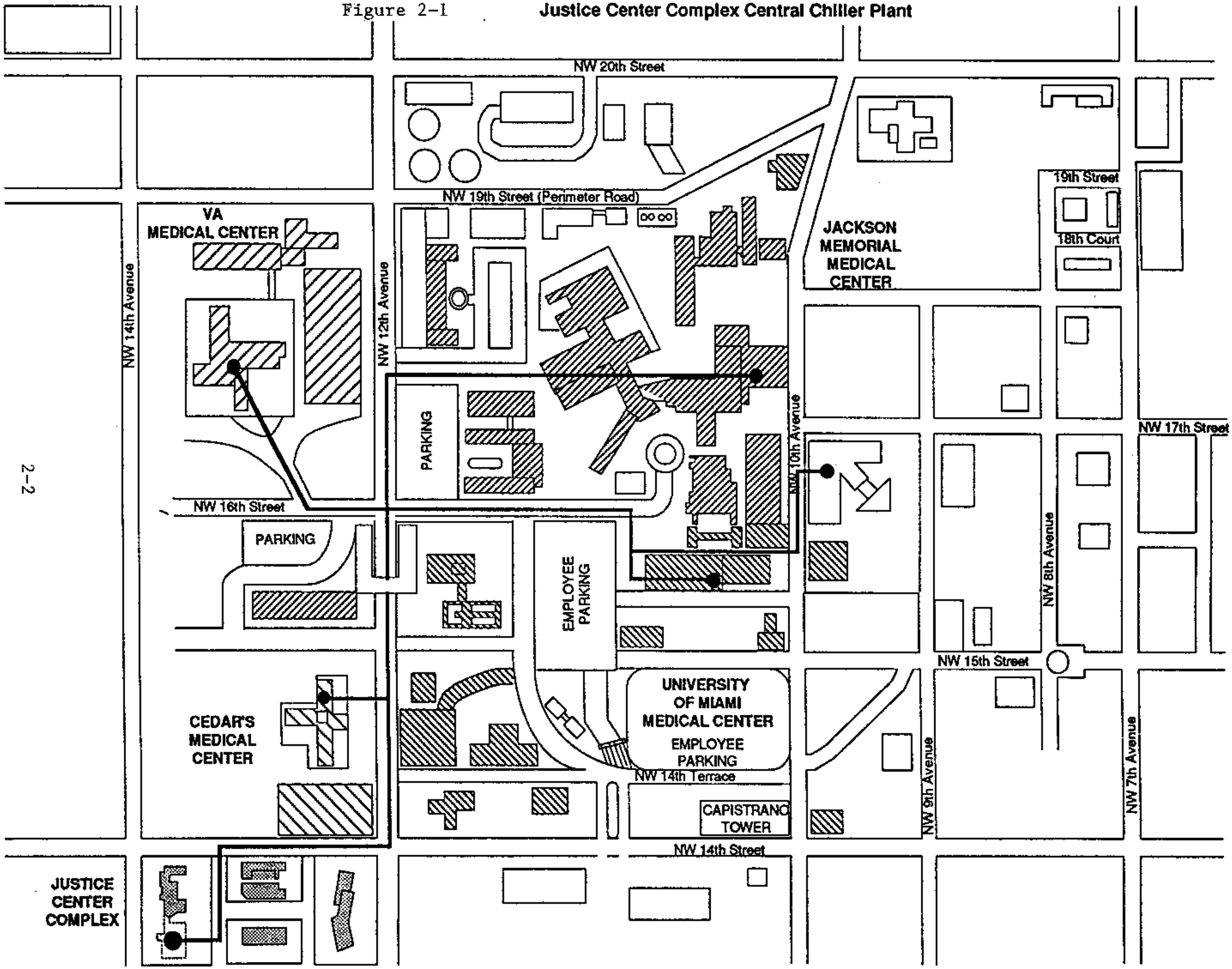
C. Test and evaluate volumetric capacity of both supply and absorption test wells.

D. Determine specification and quantity of wells, based upon test results.

E. Prepare equipment component specification based upon results of metallurgical study.

F. Conduct life cycle cost analysis, comparing well system with cooling towers; finalize decision regarding choice of cooling source.

Figure 2-1 **Justice Center Complex Central Chiller Plant**



2.2 Technical Considerations

A detailed analysis for justification of well water cooling for the Justice Center chiller water plant has been performed by Mr. A. A. Rodriguez of the DDFM Department. The results of the study are presented below:

- The project has the endorsement of the County's architect and engineering consultant as well as the engineers on DDFM's staff. Engineering considerations have been adequately reviewed and established; and appropriate recommendations made.
- There are significant environmental benefits for the community and for Dade County:
  - 1.0 Chemical hazards from handling chemicals for water treatment are eliminated.
  - 2.0 Potential for diseases such as Legionnaire's are also eliminated. A recent magazine article on this issue is enclosed.
  - 3.0 In addition, recycled well cooling water provides a substantial contribution to the County's water management program by conserving forty-five million gallons (45 MM gallons) yearly of municipal treated water.
  - 4.0 And, the project will also contribute greatly to the constraints imposed on Dade's sewage system by relieving nine million gallons (9MM gallons) yearly of chemically laden cooling tower sewage.
- Comparative costs favor well water cooling.
  - 1.0 A capital cost estimate of wells vs. cooling tower was performed, and depending on the cooling tower selected, the difference ranges from \$330,000 favoring cooling towers to \$260,000 favoring wells. The consultant had estimated a difference of \$460,000 favoring cooling towers last year, and this figure remains very conservative for the purpose of confirming the payback with wells.
  - 2.0 The yearly savings realized operating with wells have increased from \$159,000 estimated last year, to \$183,000 estimated now. This is primarily due to the increase in the cost of operating the fans for the cooling towers selected for comparison by the consultant. The comparative savings are as follows:

Description	Yearly Savings (Thousands)		25 Years Savings (Thousands)	
	Previous Report	This Report	Previous Report	This Report
Water	76	77	1,900	1,925
Chemicals	28	28	700	700
Maintenance	(3)	1	(75)	25
Chiller Efficiency	54	54	1,350	1,350
Power (Fan/Pumps)	4	23	100	575
Total	159	183	3,975	4,575

If we use the conservative differential figure of $460,000 for 3,000 tons, and project $625,000 for 5,000 tons; then based on 5,000 tons, the simple payback is 625000/183000, or, 3.42 years. This compares with the previous projected simple payback of 3.90 years.

- The above figures do not include the cost savings accruing the County from not having to treat nine million gallons (9MM gallons) of sewage effluent which would be generated by a cooling tower. In the past this cooling tower effluent was disposed through the storm drainage system and went to canals. New environmental regulations restrict disposing of this chemically treated water to surface waters, and must now be treated together with the sewage steams. the cost savings using today's WASAD sewage treatment rate is:

$$Cost\ Saving\ \$ = \frac{9\ x\ 10^6\ gallons/yr}{7.48\ gallons/cubic\ ft.}\ x\ \frac{1}{100}\ x\ \$1.0607\ /\ hundred\ ft.^3$$

$$Cost\ Savings\ \$ = 12,763 per\ year$$

Taking this credit in consideration a conservative payback is now:

$$Years\ payback = \frac{\$625,000}{\$183,000 + \$12,800} = 3.19\ years$$

- This evaluation has not taken in consideration the certain rise in WASAD's water rates, which are evident for the near future in light of the capital expenditures contemplated by that Department. The entire cooling system capitalization, without escalation nor interest, can be recovered with yearly savings in approximately $1,020,000/($183,000 + $12,800) =5.21 years. Far ahead of the planned retirement of the wells.

WATER CONSUMPTION

Water consumption is a function of the rate of evaporation required to remove the heat produced by the chiller(s), and of the chemical concentration used in the treatment to prevent scaling and to maintain salts in solution.

The heat produced by the chillers is approximately 15,000 Btu per hour per ton of refrigeration, and if necessary can be accurately obtained from any given chiller performance characteristics. However, for this analysis we will use the approximate value.

Likewise, the heat absorbed by evaporation at atmospheric pressure is approximately 970 Btu per pound of water evaporated.

The chemical concentration experienced in most applications in Dade County with a good treatment program is approximately five (5) cycles.

From the foregoing, the water consumption is calculated as follows:

1.0 Annual Tonnage

The annual tonnage is projected based on three (3) 1,000 Ton chillers operating for an initial period of five (5) years with a load factor of 48%:

Tonnage= 3 Chillers X 1000 Tons X 365 Days X 24 Hrs per day X 0.48
Tonnage= 12.6 MM Ton-Hours per year for the first five (5) years.

During the ensuing 20 years the annual tonnage projected is based on five (5) 1000 ton chillers operating with a load factor of 48%:

Tonnage= $\frac{12.6 MMTon-Hrs}{3 Chillers} X 5 Chillers = 21.0 MMTon - Hours$ per year

The weighted average annual tonnage is then:

Annual Tonnage= $\frac{(21.0 MMTon-Hours X 20 Years)+(12.6 MMTon-Hours X 5 Years)}{25 Years}$
Annual Tonnage= <u>19.32 MM Ton-Hours per year</u>

2.0 Heat Produced

Q Btu's=$15000 Btu/Hr/Ton X 19.32 MMTon - Hr/Year$
Q Btu's= $2.90 X 10^{11}$ Btu's per year

3.0 Evaporation

E= $\frac{2.9X10^{11}Btu/year}{970Btu/pound} = 299MM$ pounds of water evaporated per year

E (in gallons)= $\frac{299MMPoundswater/year}{8.34Poundswater/gallon} = 35.85MMGallonsperYear$

4.0 Water Consumption

Water consumption from limited municipal water supply is calculated from the evaporation rate and the chemical concentration used in the water treatment program.

$$W = \frac{Evapopration}{(Cycles-1)} XCycles = \frac{35.85X10^6 Gallons/Year}{(5-1)} X5 = 44.81MMGallons$$

Thus, water consumption using a cooling tower is projected at forty five (45) million gallons per year. Of this, nine million gallons (45MM-36MM = 9MM) are disposed in the sewer system yearly.

MUNICIPAL WATER COST

5.0 Water Cost from WASAD

Current water cost (April 1993 water bill) exclusive of sewer charges is $1.28 per one hundred (100) cubic feet.

$$Win100's\ cubicfeet = \frac{45X10^6 Gallon/year}{7.48Gallons/cubicfeet} X \frac{1}{100} = 60,160\ Hundreds\ of\ cubicfeet$$

Water Cost= $60,160\ hundred\ cubicfeet\ X\ \$1.28\ per\ hundred\ cubicfeet$

Water Cost= $77,005 per year.

CHEMICAL TREATMENT COST

6.0 Chemical Treatment Cost

From County records, the chemical treatment cost is $0.63 per thousand (1000) gallons of water consumed (make-up water).

Treatment Cost= $\frac{45X10^6 gallons\ water\ consumed/year}{1000Gallons} X\,\$0.63 =$
Treatment Cost= $28,350 per year

CLEANING & MAINTENANCE COSTS

7.0 Cooling Towers Vs. Wells

7.1 Cooling Towers

Maintenance, based on 15-20 years life of internal fill, $3,300 per year.

Cleaning, based on one yearly cleaning, $700 per year.

Total for three (3) towers: 3 X $4,000 = $12,000 per year

7.2 Wells

Maintenance, based on 15-20 years life on four pumps, $11,000 per year.

Cleaning is not required.

Total for four (4) pumps: $11,000 per year

7.3 Savings with wells

Savings $12,000 - $11,000 = $1,000 per year

CHILLER PERFORMANCE IMPROVEMENT

8.0 Performance Improvement

The chillers, when using well water at 78 degrees F. instead of cooling tower water at 85 degrees F., will improve the coefficient of performance, due to a reduction in the condenser pressure. The corresponding condensing pressure of the refrigerant at 78 degrees F. is significantly lower than at 85 degrees F., thus, the compressor will work with less effort while moving the same mass of refrigerant. For any given compressor characteristics and refrigerant properties there is a corresponding improvement with the reduction of the condenser cooling medium temperature (water in this situation).

The improvement varies with any given output capacity. Fortunately, computer programs are available from manufacturers, certified correct by independent organizations such as "ARI" (American Refrigeration Institute), to assist users with the performance analysis. To approximate "real life" conditions, the program is configured to provide performance data with "weighted" loading averages (output capacities) for a sustained time period. This approach is called "APLV", meaning "Application Part Load Values" of performance.

For the Justice Center, using APLV's ARI-550 values (or approx.for titanium tubes) the chiller's compressor power consumption is as follows:

York Model YKQ2Q2HI-CZAS, run date 10/22/91, APLV 0.613 Kw/Ton, with well water at 78 degrees F., and titanium tubes.

York Model YKQ2QHI-CAA, run date 10/22/91, APLV 0.653 Kw/Ton, with cooling tower water at 85 degrees F., and copper tubes.

Note: The program for well water was run with a constant 78 degrees F. cooling water supply. The program for cooling tower water was run with varying cooling water supply temperatures, up to a max. of 85 degrees F., since at lesser capacities it is assumed the compressor is operating during evening or winter hours when the cooling tower water temperature will be lower and the compressor will be more efficient.

The cost of power is approx. $0.07 per Kw-Hr.

8.1 Compressor power cost with well water

Power Cost = 19.32MM Ton-Hrs X 0.613 Kw/Ton X $0.07/Kw-Hrs
Power Cost = $829,021 per year

8.2 Compressor power cost with cooling tower water

Power Cost = 19.32MM Ton-Hrs X 0.653 Kw/Ton X $0.07/Kw-Hrs
Power Cost = $883,117 per year

8.3 Chiller performance improvement

Improvement with wells = $883,117 - $829,021 = $54,096 per year

OTHER POWER COSTS

9.0 Power costs difference

The cooling towers require fans to effect cooling by scrubbing the air against the fine water particles in the cooling tower. They also require pumps to move the cooled water through the chiller's condensers. The towers, for this analysis, are selected in multiples of 1,000 tons rated capacity. Thus, for three 1,000 ton chillers, there are three 1,000 ton cooling tower cells. Generally, in Central Chiller Plants, such as this one for the Justice Center, one additional cell is provided to serve as spare and to permit isolation and thorough cleaning of a cell without having to shut down the entire cooling system. This hygienic procedure is necessary to prevent rampant growth of disease bearing bacteria such as Legionnaire's desease and other pathogenic microorganisms. Therefore this analysis is made with three operating cells and one isolating cell, for a total of four (4) 1,000 ton cells.

The wells do not require fans, and the well's vertical turbine pumps have sufficient power to move the water through the chiller's condensers and out to the disposal wells.

9.1 Cooling Tower

Fan power per cell depends on the efficiency of the tower to effect cooling. In a typical Ceramic Cooling Tower ™ which costs in the range of $270 - 320 per ton, the fan power required for 1,000 tons cell capacity is 40 HP. In a typical commercial cooling tower of good quality which costs in the range of $190 - 230 per ton, the fan power required for 1,000 tons cell capacity is 80 HP (Approx. 60 Kw).

The daily cooling tower operation for 3,000 tons chiller demand would be similar to this for a "typical commercial cooling tower"[1] :

Time Hours	Tons Load	Kw	Number of Cells	Kw-Hr
3	1000	60	One	180
7	1001+	120	Two	840
14	2001+	180	Three	2,520
24				3,540

[1] From "ARI's" average part loads and weighted times: 100% load 10% of the time; 75%load 50% of the time; 50% load 30% of the time; and 25% load 10% of the time.

For 5,000 tons chiller capacity, the daily power consumption would be:
$\frac{3{,}540 Kw\text{-}Hr/day}{3{,}000 Tons} X \frac{5000 Tons}{1} = 5,900\ Kw - Hr$

The weighted average power consumption for a 25 years life would then be :

Fan Power $= \frac{(5 Years\ X\ 3{,}600 Kw\text{-}Hrs) + (20 Years\ X\ 5{,}900 Kw\text{-}Hrs)}{25 Years} = 5,440 Kw - Hrs$

With a Load Factor established earlier of 48% (See Water Consumption section), the equivalent operating days are: 0.48 X 365 days/Year=175 Days.

And, the Fan Power per year is then:

Fan Power per year = 175 $OperatingDays X\ 5,440 Kw - Hrs/Day$
Fan Power per Year= 952,000 Kw-Hrs.

Pump power is also required to move the cooling water through the condensers and up to the distribution deck of the cooling tower. Pump power is a function of the gallons per minute passed through the pump, the differential pressure required to push the water through the system, and the efficiency of the pump under those conditions.

The gallons per minute can be calculated from the heat to be removed from the chillers which was determined earlier under the section "Water Consumption", as 2.90X10^{11} Btu's per year. With 10 Degrees temperature difference, the formula for GPM is as follows:

GPM= $\frac{Btu's\ per Hour}{Differential Temperature X 8.34 Pounds/Gallon X 175 Days Operating X 24 Hrs X 60 Min/Hr}$
GPM= $\frac{2.9 X 10^{11} Btu's/Year}{10 Deg.F X 8.34 Lb/Gal. X 175 Days X 24 Hrs/Day X 60 Min/Hr.} = 13,798 GPM$

Assuming a pressure loss through the system of 69 feet TDH, and a pump efficiency of 75%, the Pump Power is then:

Pump Power $= \frac{GPM\ X\ Total Dynamic Head\ X\ 0.746 Kw/Hp}{3960 X Pump Efficiency}$
Pump Power $= \frac{13798 GPM X 69 Feet TDH X 0.746 Kw/Hp}{3960 X 0.75} = 239 Kw$

With a motor efficiency of 90%, the pump motor power is then:

Pump Motor Power=$\frac{239Kw}{0.90} = 266Kw$

The Yearly Pump Power is then:

Yearly Pump Power = 266KwX175DaysX24Hrs/Day
Yearly Pump Power = 1,117,200 Kw-Hr

Total Cooling Tower Power Consumption=952,000+1,117,200
Total Cooling Tower Power Consumption= 2,069,200Kw-Hrs.

Total Cooling Tower Power Cost=2,069,200KwHrX$0.07/KwHr
Total Cooling Tower Power Cost=$144,844 per year

9.2 Wells

The power required to pump the water from the wells, through the chiller's condensers and out to the disposal wells is calculated from:

Well's Pump Power=$\frac{GPMXTDHX.746Kw/Hp}{3960XPumpEfficiencyXMotorEfficiency}$
Well's Pump Power=$\frac{13,810GPMX115feetX0.746Kw/Hp}{3960X0.8X0.9} = 416Kw$

Yearly well pumping power=$416KwX175DaysX24Hr/Day$

Yearly well pumping cost= 1,747,200Kw-Hr X $0.07/Kw-Hr

Yearly well pumping cost= $122,304.00

9.3 Power Cost Difference

The power cost difference favors using wells by:

$144,844 - $122,304 = $22,540 per year

CAPITAL COST ESTIMATE

1.0 Cooling Towers

1.1 Installed, including piping and pumps, electrical, instrumentation and foundations, etc., with PVC type of fill formed in the tower sides, they cost:

15-20 years life, \$190-230 per ton

1.2 Installed, as above, but long life, similar to a Ceramic Cooling Tower™, with ceramic type fill, they cost:

40-45 years life, \$270-320 per ton

We would recommend for a Central Chiller Plant, such as the one contemplated for the Justice Center, a field erected tower with concrete basin and ceramic type fill; three (3) 1,000 tons cells operating plus one (1) 1,000 tons cell spare to rotate and clean and to serve as an alternate in case of fan failure in one of the operating cells.

The cost for this recommendation would be : 4 cells @ 1,000 Tons capacity each, @ \$270-320 per ton = \$1,080,000 to \$1,280,000 with 40-45 years life.

This is in contrast with a quality prefabricated PVC fill type tower, which for the same capacity of three (3) 1,000 tons cells plus one (1) 1,000 tons spare celll, would cost \$760,000 to \$920,000.

Another alternative, <u>which is not recommended</u> for the Justice Center Central Chiller Plant is to have the least expensive commercially prefabricated tower, 15 years life, with a minimum of cells, namely three (3) 1,000 tons cells. The cost for this alternate would be a very attractive \$570,000 to \$690,000.

2.0 Wells

A review of the 75-80% submission drawings supports a cost for the wells as follows:

Four (4) pumps	160,000
Nine (9) wells	180,000
Titanium Tubes in Chillers	340,000
Piping (Includes excavation and assembly)	130,000
Electrical & Instrumentation	40,000
Total for wells	850,000
Contingency (20% recommended at this time)	$1,020,000

The wells will cost $850,000 to $1,020,000.

3.0 Differential Cost

Wells 25 Years Life	3 Cells CT PVC Fill 15 Years Life	4 Cells CT PVC Fill 15 Years Life	4 Cells CT Ceramic 40 Years Life
$ 850,000	$ 570,000	$ 760,000	$1,080,000
$1,020,000	$ 690,000	$ 920,000	$1,280,000

The differential costs of Wells Vs. Cooling Towers depend on the type of tower and the number of cells.

3.1 Wells Vs. 3 PVC CT, the difference is 850,000 - 570,000 = 280,000
1,020,000 - 690,000 = 330,000

3.2 Wells Vs. 4 PVC CT, the difference is 850,000 - 760,000 = 90,000
1,020,000 - 920,000= 100,000

3.3 Wells Vs. 4 CCT, the difference is 850,000 - 1,080,000= (230,000)
1,020,000- 1,280,000= (260,000)

The differential cost between wells and cooling towers ranges from $330,000 favoring cooling towers, to $260,000 favoring wells.

2.3 Hydrogeological Services for the Test Well Program

The objective of this testing program is to evaluate the ground water conditions at the subject site as related to the proposed closed ground water cooling system for the Justice Center Support Facility. The cooling system would involve withdrawing 15,000 gpm from a network of wells in the Biscayne aquifer at the site using the water to cool the air conditioning units and returning the water to the Biscayne aquifer through a different network of recharge wells also on the site.

The following data are necessary to meet the objectives of the project:

- lithologic profile of the aquifer
- most suitable designs for withdrawal and recharge wells
- water quality and water temperatures in aquifer
- specific capacity/efficiency of wells
- aquifer parameters
- recharge well capacity
- interaction between the withdrawal wells and recharge wells

The following work elements have been identified for this project:

1a. Construct core borings at three well sites.
1b. Provide permit support services.
1c. Provide inputs on plans and specifications for the installation and testing for a withdrawal well and a recharge well.
2a. Monitor the installation and specific capacity testing of the two wells.
2b. Install monitor well
3. Oversee three field tests
    - Aquifer performance test to determine aquifer parameters at the site.
    - Well performance test to determine recharge well capacity.
    - Tracer test to evaluate interaction between withdrawal and recharge wells.
4. Analyze test results including computer modeling.
5. Prepare final report.

Work Element 1A:

Perform core boring at each of three well locations.

Drill a core boring to ascertain the soil profile, to aid in finalizing well depths and casing lengths for the plans and specifications of the withdrawal and recharge wells. The boring terminated at 150 feet below land surface.

Work Element 1B:

Provide permit support services including Phase I Environmental Audit of the site area.

Participate in the permit effort with the south Florida Water Management District (SFWMD) and the Florida Department of Environmental Regulation (FDER) as needed. These permits deal with the consumptive use of water for the project as well as for the Group V, Class I injection (recharge) wells for the project. The permitting effort is under the direction of the County. A Phase I Environmental Audit can also be performed if requested to assess potential for historic environmental contamination in the area. Project team members may perform tasks or attend meetings at the request of the County on an as needed basis.

Work Element 1C:

Review and comment on a set of plans and specifications for the test well program.

In this work element the technical plans and specifications for the installation of the two wells and the three field tests will be refined through review and inputs to a draft prepared by others. The work effort will involve refinement of the technical specifications, assistance during the bid process, evaluation of bids and attendance at a pre-construction meeting with the selected contractor. The following items are important elements of the specification document:

- Well Details
  - casings (e.g., materials, diameters, lengths)
  - collection zones (e.g., materials, diameters, lengths)

- plumbness/alignment
- grouting
- clearing/development

- Procedures and Equipment
  - sand test
  - specific capacity/well efficiency test
    * specific capacity of each well at 1000, 2000,300 gpm for 2 hours at each pumping rate
    * discharge water to appropriate placewater chemistry test
    * measure water temperature in well during pumping period
    * take water sample at end of pumping period for water chemistry analysis

- Pilot Hole/test Drilling
- Sample Collection and Logs
- Analytical Chemistry Data
- Clean up
- Capping
- As-built Documentation

Work Element 2A:

Monitor the well installation program.

Monitor the installation of the two large diameter withdrawal and recharge wells constructed by the outside water well contractor. Assist in collecting geological samples, deciding the depth to which the casing is set, monitor well grouting and determine the total depth of the well. In addition, monitor final well testing program at each well by the contractor. This testing could involve specific capacity/well efficiency pumping, sand test and possibly borehole logging.

Work Element 2B:

Install monitor well near SW-e well location.

Install monitor wells (s) approximately 25 feet east of the SW-3 well for purposes of monitoring water levels and water temperature during the test period as well as to serve as a long term monitoring well for the project. The monitoring well is proposed instead of the SW-3 well in the field test program. A 2-inch diameter monitor well is budgeted for 150 feet.

Work Element 3:

Conduct the pump tests including taking water samples as set forth in the scope of work.

This work element involves the support services to oversee the three pump test programs performed by the water well contractor under the scope of the plans and specifications:

Test No. 1

- Pump SW-1 at 3000 gpm for 24 hours. Document flow rates and measure drawdown in SW-1, MW near SW-3 and DW-1 and water level in adjacent surface waters during pumping period.
- Discharge water to appropriate place.
- Monitor recovery in SW-1, MW and DW-1 after pumping has stopped.
- Measure water temperature in well during pumping period every three to four hours.
- Take water samples at start and at end of pumping period for water chemistry analysis.

Test No. 2

- Inject water into DW-1 at 2000 gpm for 24 hours. Document flow rate and measure water levels in DW-1, SW-1 and MW.
- Measure water temperature in well every hour during pumping period.
- Take water samples at start and at end of pumping period for water chemistry analysis.

Test No. 3

- Pump SW-1 at 2000 gpm for 5 days and dispose of water in DW-1. Inject tracer, probably bromide, into water stream. Document flow rate and tracer concentration going into DW-1 and measure water levels in SW-1, MW and DW-1 during test period.
- Collect water sample every half hour in SW-1 for laboratory analysis of bromide.
- Analyze bromide samples each day to determine movement of tracer in ground water and to aid in making a decision on termination of test.
- Take water samples at start and at end of pumping period from SW-1 for water chemistry analysis.
- Monitor recovery conditions in SW-1, MW and DW-1.

The water levels, the pumping rate, the water temperature and the water quality characteristics of the aquifer system will be documented during the pump testing efforts. Frequent documentation of water levels and pumping rate during the pump test 1 and pump test 2 are extremely important to determine aquifer transmissivity and storativity. The documentation of the water temperature and the water quality conditions are necessary design data. The water samples will be collected at the same time that the temperature reading are taken. The cost for chemical analyses by a certified laboratory, except for bromide, will be paid by the water well contractor as part of the provisions in the plans and specifications.

Water temperature data will be primarily collected during the pumps of the withdrawal well and during specific capacity testing of the withdrawal and recharge wells. It is recommend that a data logger be installed to document water levels in the pumped well and observation wells on a continuous basis during the three field tests. Continuous records of drawdown and recovery water levels are desirable to accurately determine aquifer coefficients.

The rise in temperature with time at the supply wells because of the injecting heat water in the disposal wells is a factor that needs evaluation during a field test program. It is proposed to perform a dye or tracer study in the field test No. 3. A tracer such as bromide will be injected continuously in the recharge well and its effects on the withdrawal well will be monitored with time. This type of test is deemed important in establishing interaction of water between the withdrawal and recharge wells and optimum spacing. Costs for the field effort is based on a maximum duration for the pumping period for Test No. 1 and 2 to be 24 hours each and 5 days for Test No. 3.

Work Element 4A:

Analyze field data, develop and run a computer model to establish the blended water temperature after chill water return at elevated temperature is injected into the aquifer.

This work element will involve the data reduction and analysis of the field data and other existing data to develop and run a computer model to establish the blended water temperature after chill water return at elevated temperature is injected into the aquifer based on the proposed well layout. USGS MODFLOW and HST#D models will be used in this modeling effort. The computer model will be set up to evaluate two or tree different well layouts for withdrawal and recharge wells to optimize project objectives.

Work Element 4B:

Evaluate water level results from work element 4A with regard to possible geotechnical impacts to foundations near wells.

This work element will involve the geotechnical evaluation of possible adverse impacts to foundations within the area of influence of the wells. The foundation designs for structures in the area will be researched to document foundation conditions.. Such design data as elevation of foundation, thickness of foundation, pile lengths and number of piles will be ascertained form available documents. The water level conditions as predicted under the well plan will be superimposed on these foundations to ascertain any possible adverse impacts.

Work Element 5:

In this work element the final report will be prepared summarizing the field test results, analyses and also providing conclusions and recommendations. The report will summarize the field data, analyses, modeling results, geotechnical evaluation and make conclusions/recommendations for future actions as appropriate.

The outlined program is now in the implementation stage.

SECTION 3

PROVIDENCE DISTRICT HEATING AND COOLING PROJECT

3.1 Introduction

The objective of this project was to assess the opportunities for implementing a community energy system based on district heating and cooling in the City of Providence. The goal of the project was to formally market DHC to the individual building owners and develop the thermal source, and outline the plan for the implementation of the project.

The main district heating and cooling source in the City of Providence is the Manchester Street Station located in close proximity to the downtown area of Providence. This old power plant constructed in 1903 is presently being repowered from a conventional steam turbine based plant to a modern combined cycle power plant. The plant capacity of the plant will increase from present 132 MW to 489 MW. The plant will be equipped with three combined cycle units each with the capacity of 163 MW. The plant net heat rate will be improved from about 12,000 Btu/kWh to 8,000 Btu/kWh. The station will fire primarily natural gas with No. 6 oil as a back up. Presently the plant is under construction and is scheduled to begin operation at the end of 1995.

During the permitting process the Rhode Island Energy Facility Siting Board requested that the station must make available up to 150,000 lbs/hr of steam for sale. A preliminary proposal by the New England Power Co. for steam supply from the Manchester Street Station provided 50,000 lb/hr of steam on an interruptible basis for a 5 year term with extensions. The cost of steam was based on a pricing formula, where the price of 1000 lbs of steam equals 62.5 times the energy rate, as determined on a monthly basis in accordance with the Rhode Island public utilities Docket No. 1549. The steam is supplied from the second extraction point on the steam turbine. The basis for this pricing proposal is that steam sales will reduce the electrical output of the Manchester Street Station. The pricing, which is tied to Narragansett Electric's avoided energy cost, is determined in a manner that will enable the company to obtain the reduced electrical energy from other sources.

The utility has indicated that to assure the reliability of supply the heat users must have standby capacity in the event of steam sale interruptions by the New England Power pool dispatch of Manchester Street Station.

In order to supply heating and cooling from the Manchester Street Station, the installation of steam to hot water heat exchangers and absorption chillers to convert the steam to hot and chilled water has been proposed. Ideally the required equipment may be located on the station's site, although a nearby substation is also acceptable. From the substation a four-pipe transmission system (two pipes for hot water and two pipes for chilled water) will be installed. In addition, a four-pipe distribution system will be installed in the district in order to deliver hot and chilled water to the customers.

Although the Manchester Street Station alternative offers inexpensive steam, it requires a long transmission system to reach the downtown customers. Considering this additional cost and the interruptibility of steam supply, the second central energy source alternative has been developed. This option for the development of DHC in downtown Providence involves an independent central energy source near the end-users, in lieu of the Manchester Street Station supply. This independent plant is more appealing for the first development stage since it may be located closer to the service area. This plant may be installed in either an existing or new structure or incorporated in new development. Design simplicity and lower cost allow rapid implementation to launch a DHC program to a limited area. When this phase of the development is implemented the independent plant can be connected with the Manchester Street Plant.

A detailed assessment of potential customers in the downtown of Providence has been performed. Based on the high load density the Financial District was selected as a prime candidate for the first development stage. The peak heating load for this district is about 60 MMBtu/hr and the cooling load is 7,000 tons.

The independent central plant to be installed close to the Financial District will be equipped with gas/oil fired boilers or a cogeneration unit and a combination of absorption and electric chillers. In addition a four-pipe distribution system will be installed in the financial district.

3.2 Service Area

The City of Providence, the state capital, is situated on the eastern border of Rhode Island along the Providence River. Providence has a cold climate with about 6000 heating degree days. The outdoor design temperature is 3°F

Major factors in the heating and cooling load assessment are the area thermal load density and the proximity of the load to the thermal source. Based on the high density of large buildings in the Financial District and their proximity this area was selected for a comprehensive load analysis. Information to support the load assessment was accomplished primarily by on site surveys. Customers selected would serve to "anchor" the system, characterized by a thermal usage sufficient to permit the construction of a district energy system in an economically viable fashion.

A detailed survey of potential customers in the Financial District of Providence aimed at obtaining the thermal loads, determining system compatibility, and establishing contacts for the marketing campaign. Findings of the building surveys are summarized in Table 3-1.

Table 3-1
Peak and Annual DHC Loads

Building Name	Sq. Ft.	Floors	Heating Load		Cooling Load	
			MMBtu/hr	*MMBtu*	*Tons*	*Tons-Hrs*
Omni Biltmore Hotel	333,000	18	10.00	18,000	830	720,000
City Hall	96,800	5	2.05	2,285	260	156,800
Westminister Square	203,000	12	3.21	3,385	584	328,860
Fleet National Bank	375,000	30	9.00	13,340	937	562,000
Fleet Center/Phenix Bldg.	412,000	20	5.56	5,817	783	469,800
Hospital Trust Tower	490,000	30	9.63	12,207	1200	720,000
Hospital Trust Building	350,000	12	7.31	5,035	800	480,000
Amica	170,000	10	2.39	2.793	440	264,000
Turks Head	147,000	16	3.63	4.712	390	234,900
40 Westminister	338,000	22	7.95	10,550	700	421,200
TOTAL	2,914,800		61.00	78,124	6,924	4,357,560

3.3 District Energy Sources

A strategy of staged implementation characterized by the interconnection of the service area to the Manchester Street Station over a period of several years is presented in this section. Phased implementation is desirable offering lower capital cost and time for prospective customers and developers to acquire confidence in the system.

Two central energy source options are developed: Manchester Street Station and an independent energy plant in close proximity to the Financial District.

The first option focuses on the integration of a district heating and cooling system (DHC) in the City of Providence with the repowering of Narragansett's Manchester Street Station. This integration capitalizes on the opportunity to use available steam from the electric utility, New England Power Co. (Narragansett Electric) to provide district energy services to the Financial District in downtown Providence. The proposed service area exhibits favorable load densities for DHC, which may be developed in parallel to the repowering of the Manchester Street Station. Available steam from the repowering project may be used for an anchor DHC system in the Financial and adjacent districts.

Manchester Street Station

New England Power Co. and Narragansett Electric Co.'s Manchester Street Station was built in 1903 to supply dc electricity for Providence's street cars. By 1941, a 44-MW coal-fired steam turbine driving an ac generator was put into operation followed by two more coal-fired units in 1947 and 1949. During the early 1960's the units were converted to fire No. 6 fuel oil and then in the 1980's modified to fire natural gas as an alternative fuel.

Because of their poor heat rate and efficiency (approximately 12,000 Btu/kWh or 28 percent), these non-reheat units with main steam conditions of 1,250 psig/950°F operated with only a 15 percent capacity factor and were used predominately for system reliability at peak load demands.

It became clear that it was much more attractive to revitalize the plant, rather than retire the units. In 1990, the decision was made to repower the Manchester Street Station with three V84.2 model gas turbines. These 103-MW units perfectly matched the existing three 50-MW steam turbine units.

However, very specific licensing issues had to be resolved before construction could begin. The existing and new plant buildings, for example, had to be architecturally consistent with the historically-significant plant site on the waterfront. Along with the historically-correct building style, a waterfront park was required to be included in the plan. Furthermore, the increased plant capacity required building a seven-mile underground 115-kV transmission line. Additionally, a three-mile water line from a well to the station was specified to carry non-potable water for NO_X control and power augmentation.

Thermal discharge into the Providence River also is restricted. However a once-through cooling system is being considered. The air permit restricts NO_X emission to 9ppm and CO emission to 11 ppm for operation with natural gas. NO_X emission of 25 ppm and CO emission of 11 ppm are the limits for operation with No. 2 fuel oil. The key contaminant air emissions at the site will decrease, despite a threefold increase in capacity and an estimated six fold increase in total capacity.

To improve plant performance, dual pressure steam cycles are used. To match this cycle, the steam turbines will be replaced and the new ones coupled to the existing generators. With this design, it is expected that plant capacity will increase from present 132 MW to 489 MW. At the same time, the plant net heat rate will be improved from about 12,000 Btu/kWh to 8,000 Btu/kWh, which relates to a plant net efficiency improvement of approximately 28 percent to 43 percent based on high heat value (HHV). To augment power and reduce NO_X emissions, steam will be extracted from the steam turbine and injected into the gas turbine. Duct firing was found to be uneconomical so selective catalytic reduction units will be installed to achieve required NO_X emission levels under all operating conditions. With the improved thermodynamic performance and the switch from No. 6 fuel oil to natural gas, the specific CO_2 discharge will also be drastically reduced from approximately 2 pound/kWh to 0.9 pound/kWh.

Presently the plant is under construction and is scheduled to begin operation at the end of 1995.

During the permitting process the Rhode Island Energy Facility Siting Board requested that the station must make available up to 150,000 lbs/hr of steam for sale. A preliminary proposal by the New England Power Co. for steam supply from the Manchester Street Station provided 50,000 lb/hr of 14 psig, 248°F steam on an interruptible basis for a 5 year terms with extensions. The cost of steam was based on a pricing formula, where the price of 1000 lbs of steam equals 62.5 times the energy rate, as determined on a monthly basis in accordance with the Rhode Island public utilities Docket No. 1549.

The utility offered the following pricing formula:

price per 1000 lbs steam sales (expressed in $/1000 lbs) = 62.5 x A,

where A is the energy rate as determined on a monthly basis in accordance with RI Public Utilities Docket 1549 (Total hours rate expressed in dollars per kilowatt hour).

The basis for this pricing proposal is that steam sales will reduce the electrical output of the Manchester Street Station. The pricing, which is tied to Narragansett Electric's avoided energy cost, is determined in a manner that will enable the company to obtain the reduced electrical energy from other sources.

The Manchester Street Station alternative involves the installation of steam to hot water heat-exchangers and absorption chillers to convert the steam to hot and chilled water for DHC. Ideally, the required equipment may be located on the station's site, although a nearby substation is also acceptable.

Independent Central Plant

A second option for the development of DHC in downtown Providence involves an independent central energy source near the end-users, in lieu of the Manchester Street Station supply. A 15,000 sq. ft. to 20,000 sq. ft. area on one or two floors is adequate for the initial development and the subsequent central source expansion.

The central plant will include a boiler area, a chiller area, and a pump and heat exchanger room. On the outside or the top of the structure, it will accommodate dry type cooling towers.

Although the Manchester Street Station alternative offers inexpensive steam, it requires a long transmission system to reach the Financial District. In this respect, the independent energy source operation for the first development stage is more appealing since it may be located closer to the service area. The central source may be installed in either an existing or new structure or incorporated in new development, such as the proposed Johnson & Wales building behind the Broadcast House.

The boilers and chillers would embody the latest available technology maintaining high fuel efficiencies over a wide range of operating loads. The advantages of installed conventional boilers and chillers relies on a comparatively lower installed cost and a high degree of reliability. As important is its flexibility to enable expansion of a system to develop a piping infrastructure which would be interconnected to a long term source like the power plant facility. When a larger system is designed and constructed, utilizing the cogeneration plant, the hot water boilers and chillers would be retained within the overall system to provide peaking or stand-by capacity. For purposes of a planning strategy in Providence a hot and chilled water generators option may be considered a short interim solution. Design simplicity and lower cost allows rapid implementation to launch a DHC program to a limited area.

Another independent plant option consisting of a small in-fence cogeneration plant combined with a district heating and cooling system has been developed. This scenario does not mean the export of electricity from the cogeneration plant but suggests using all power generated to drive electric chillers and run an electric boiler.

The development of a district heating and cooling system in combination with cogeneration provides flexibility in load matching. Thermal loads may be selected and incorporated in the system as required for optimal performance. It should be noted that all customers are mostly office buildings which defines the profiles of their heating and cooling loads. The peak heating load for selected buildings was estimated at 61 MMBtu/hr and peak cooling load - at 7,000 tons. These loads will be supplied from the plant which has to be built in the Financial District.

The plant will consist of a gas turbine unit including a heat recovery steam generator (HRSG) with supplemental firing, a gas fired boiler(s) to supply peaking loads and an electric boiler. The plant will also include two types of chillers to supply cooling loads - electricity driven (thereafter "electric") and absorption chillers (thereafter "thermal"). The HRSG, electric and peaking boilers will be connected to the common steam header. The steam from the header will pass through a heat exchanger to heat a district heating water and, also will be delivered to the absorption chillers installed at the plant.

3.4. Conclusion

The basis for proceeding with the district heating and cooling project is the comparison of anticipated system costs versus expected revenues and the subsequent margin between a reasonable value for the district service and the cost which can be achieved by building owners through individual systems. The magnitude of the economic advantage is measured through the determination of the unit cost of salable district heating or cooling through the evaluation of thermal sales weighed against the annual carrying charge associated with capital investments and the expenditures dedicated to the operation and maintenance of system facilities. The price obtained for the delivered district energy service is then directly compared to costs of heating and cooling experienced by individual building owners with the energy savings devoted to the payback of incurred retrofit costs during conversion.

The capital cost of the Manchester Street alternative is estimated at $17,000,000. The unit cost of heating and cooling was estimated as $8 per million Btu and $0.23 per ton-hr, respectively.

The capital cost of the independent central plant alternative is estimated at $12,400,000. The unit cost of heating and cooling was estimated as $7.6 per million Btu and $0.22 per ton-hr, respectively.

The capital cost of the independent cogeneration plant alternative is $15,000,000. The unit cost of heating and cooling was estimated as $7 per million Btu and $0.21 per ton-hr, respectively.

Based on the cost analysis, it was determined that the DHC system can supply energy at a cost lower than the cost presently paid by the individual buildings. Marketing of the DHC to the downtown customers is now in progress.

SECTION 4

JORDAN COMMONS MODEL COMMUNITY

4.1 Introduction

Jordan Commons, Homestead Florida, also known as the Homestead Habitat for Humanity, South Dade Model Ecological Community is a partnership between Habit for Humanity International, Homestead Habitat for Humanity and a diverse group of individuals, organizations and institutions. The goal of the project is to develop an energy efficient and sustainable community. Homestead Habitat for Humanity is proposing to develop a 40 acre community of approximately 200 homes, a daycare and family resource center, a community market and recreational facilities. This community will serve as a model demonstration project to document energy savings and lower ambient air temperatures.

The preliminary list of recommended energy efficiency measures have included: reflective roofs, radiant barriers, solar water heating, sealed duct air distribution systems, down sized air conditioners, low flow showers and toilets, energy efficiency refrigerators, compact fluorescent lighting and strategic landscaping. The Florida Solar Energy Center has estimated a 39% - 48% savings in electricity use. There is now an expressed interest to increase potential savings by extending the pay-pack period and incorporating additional measures such as photovoltaics, passive solar cooling design, recycled building materials and central chiller cogeneration technology.

HUD requested JTC to assess the use of district cooling/hot water for this project. The following are the results of the analysis performed by JTC.

4.2 Supply of District Cooling

This is an analysis comparing a community chilled water system to each home having a dedicated central air conditioning system. A community or district system will send chilled water (44°F) to each house through underground plastic pipes. The water will flow through a flowmeter and control valve in each home before entering a coil in the house's ductwork. This coil will take the same space as if the home had individual air conditioning, but will flow water instead of freon.

The following assumptions were used:

1. The cost of electricity is 6¢/kW.
2. The underground pipe can be installed before the street is paved.
3. A 11 by 33' flat roof building can be built above the sewage pump
4. The necessary cooling tower will fit on the roof of the above mentioned building.
5. The pumping power needed is based on a conservative 9°F temperature difference, even though 14°F is achievable.

A central chiller is designed to cool the refrigerant using a water based cooling tower. The individual house units would use hotter outside air to cool the refrigerant. This will result in 12°F lower refrigerant temperature for the central chiller, thus making the central unit more efficient than individual units.

Diversity is the concept that many customers on the same system will never all use the same service at the same time. Each house will typically require a 3 ton air conditioner, even though the real load may only be 2.5 tons. The entire complex requires 600 tons of cooling when calculated by adding up what each building would install. A central chiller, on the other hand, will only need to be sized for 400 tons due to both the elimination of a ½ ton excess capacity in each house and diversity (Table 4-1)

The central chiller selected has a 3 stage compressor. This gives the cost benefit of only having to buy one large unit while getting the efficiency of 3 smaller units. All electric compressors lose efficiency when running at less than full load. A central unit during the mild season will run at 75% efficiency as opposed to the individual house units running at 50%. This will result in a savings of electricity and therefore money.

The total cost of a central chiller system is estimated at $824,455 with an electrical service hookup cost of $8,563 for a total cost of $833,018. To install a 3 ton air conditioning unit in each of the 202 houses, a7.5 ton unit in both the store and the

Table 4-1

Sizing of the Cooling Equipment

BLDGS	SF	QTY	TOTAL SF	LOAD (tons)	STD COMP	TOTAL TONS	Red. conn. cost	SERVICE WATER	TOTAL	PIPE SIZE	LF	COST ($)
1	1,024	46	47,104	2.0	3.0	138	$27,600	5.46	251.22	3/4"	19190	59,489
2	1,215	74	89,910	2.4	3.0	222	$44,400	6.48	479.52	1"	816	3,248
3	1,222	31	37,882	2.4	3.0	93	$18,600	6.52	202.04	2"	2170	22,785
4	1,094	28	30,632	2.2	3.0	84	$16,800	5.83	163.37	3"	1670	45,424
5	784	1	784	1.6	3.0	3	$600	4.18	4.18	6"	700	32,200
6	1,272	18	22,896	2.5	3.0	54	$10,800	6.78	122.11	8"	1450	87,000
7	806	4	3,224	1.6	3	12	$2,400	4.30	17.19			250,146
Resource/Day Care	7,200	1	7,200	14.4	15	15	$3,000	38.40	38.40	1240	693	1.75 LABOR
Rec. Bldg.	10,000	1	10,000	20.0	20	20	$4,000	53.33	53.33	6.14 gal/house		
Store	3,000	1	3,000	6.0	7.5	7.5	$1,500	16.00	16.00			$437,755
Office	3,000	1	3,000	6.0	7.5	7.5	$1,500	16.00	16.00			
		206	255,632			656	$131,200		1363.37	123.73		

RESIDENCES- 500 SF/ton		500					
TOTAL TONS CAPACITY REQ'D		511	vs.	656	SAVE	247	tons
ELEC. SERVICE	693 amps	$8,563	vs.	$131,200	SAVE	$122,637	
single home	16 amps						
		TONS	DELTA T	FLOW			
DIVERSITY	0.80	409	9	1,091			

DISTRICT COOLING PIPE SIZING CHART @ 53-44F

NOM. PIPE SIZE (in.)	FLOWRATE (gpm) @ 5 fps	COOL LOAD (MBH) @ 5 fps	FLOWRATE (gpm) @ 8 fps	HEAT LOAD (MBH) @ 8 fps
3/4	9	41	14	63
1	15	68	24	108
1 1/4	26	117	42	189
1 1/2	35	158	56	252
2	56	252	90	405
2 1/2	94	423	150	675
3	129	581	206	927
4	218	981	348	1,566
5	333	1,499	533	2,399
6	488	2,196	780	3,510
8	837	3,767	1340	6,030

NOTE: An initial design which uses 5 fps will have the ability to carry more heat at the max. of 8 fps.

office, a 15 ton unit in the Resource/Day Care Center and a 20 ton unit in the Recreation building is estimated at $936,700.

Since the houses are not large (typically 1,200 square feet), and a dishwasher is not being installed, it is assumed that a 100 amp electrical service will be all that is required. It is then assumed that installing central air conditioning in each house will require a larger 200 amp service. The extra cost for each house ($600) adds up to a total increase of $131,200.

Therefore, a district cooling system will save $122,637 in avoided electrical service connection costs. This savings added to the reduced capital cost of a central chiller will result in a savings of$234,883 to the Jordan Commons complex. The maintenance costs are also expected to be lower for a district chiller. The attached Table 4-2 "Cooling Plant Economic Analysis" shows that over the 20 year life the equipment, the central chiller option will save $5,868,160. Another important advantage is the elimination of the space consuming and noisy compressor that would otherwise have to be installed alongside each house.

Some options to be further investigated are as follows:

- Use evaporative cooling instead of conventional cooling towers. This will conserve water, lower the refrigerant temperature for increased operating efficiency. In the mild weather, the evaporative cooler will provide free cooling, thus saving energy and extending the life of the compressor.
- Install a heat exchanger for free cooling if an evaporative cooling is not chosen.
- Install 2-200 ton machines instead of one 400 ton so that maintenance can be done without disrupting service
- The chilled water circulating pump can be smaller and consume less electricity if a 14°F temperature is designed for and felt realistic.

4.3 District Domestic Hot Water Analysis

It is understood that no natural gas is available in the Jordan Commons complex. It is under consideration to install propane tanks for each house. Under that assumption, gas will be available for cooking and domestic hot water generation. This will allow cheaper generation of domestic hot water than if electric heaters

TABLE 4-2
COOLING PLANT ECONOMIC ANALYSIS

Assume 20 year chiller life
Escalate electricity at 7% per DOE projections.

CENTRAL COOLING PARAMETERS		
Cooling		
Peak Cooling Demand	400	tons
Equivalent Full Load Hours	4,114	
Annual Cooling Demand	1,645,600	ton-hrs
Chiller Electricity Use	1,003,816	kwhrs
Pumping & CT Electric Use	768,082	kwhrs

ECONOMIC PARAMETERS		
Cost of Money	6.0%	
Escalation		
Electricity	7.0%	
General Inflation	4.0%	
Owner Operated Energy Costs		
Electricity	$0.06	/kwhr

HOMEOWNER COOLING PARAMETERS		
Cooling		
Peak Cooling Demand	600	tons
Equivalent Full Load Hours	4,114	
Annual Cooling Demand	2,468,400	ton-hrs
Chiller Electricity Use	1,505,724	kwhrs
Pumping & CT Electric Use	768,082	kwhrs

CENTRAL CHILLER PLANT

Year	Capital Cost	Chiller Elect. Cost	O&M Costs	Total Cost
0	$824,455	$8,563		$833,018
1	$0	$106,314	$13,333	$119,647
2	$0	$113,756	$13,866	$127,622
3	$0	$121,719	$14,421	$136,140
4	$0	$130,239	$14,998	$145,237
5	$0	$139,356	$15,598	$154,954
6	$0	$149,111	$16,222	$165,332
7	$0	$159,548	$16,870	$176,419
8	$0	$170,717	$17,545	$188,262
9	$0	$182,667	$18,247	$200,914
10	$0	$195,454	$18,977	$214,431
11	$0	$209,135	$19,736	$228,872
12	$0	$223,775	$20,526	$244,301
13	$0	$239,439	$21,347	$260,786
14	$0	$256,200	$22,200	$278,400
15	$0	$274,134	$23,088	$297,222
16	$0	$293,323	$24,012	$317,335
17	$0	$313,856	$24,972	$338,828
18	$0	$335,826	$25,971	$361,797
19	$0	$359,334	$27,010	$386,344
20	$0	$384,487	$28,091	$412,578
Total	$824,455	$4,366,952	$397,031	$5,588,438

HOMEOWNER PRODUCED COOLING

Owner Capital Cost	Cooling Electric Cost	Owner Labor Cost	Total Cost	Cash Flow Savings Central vs. Owner
$936,700	$131,200		$1,067,900	($234,883)
$0	$238,447	$20,600	$259,047	($139,401)
$0	$255,139	$21,424	$276,563	($148,941)
$0	$272,998	$22,281	$295,279	($159,140)
$0	$292,108	$23,172	$315,281	($170,044)
$0	$312,556	$24,099	$336,655	($181,702)
$0	$334,435	$25,063	$359,498	($194,166)
$0	$357,845	$26,066	$383,911	($207,492)
$0	$382,894	$27,108	$410,003	($221,740)
$0	$409,697	$28,193	$437,890	($236,975)
$0	$438,376	$29,320	$467,696	($253,265)
$0	$469,062	$30,493	$499,555	($270,684)
$0	$501,897	$31,713	$533,609	($289,309)
$0	$537,029	$32,981	$570,011	($309,225)
$0	$574,621	$34,301	$608,922	($330,521)
$0	$614,845	$35,673	$650,517	($353,295)
$0	$657,884	$37,099	$694,983	($377,648)
$0	$703,936	$38,583	$742,519	($403,691)
$0	$753,211	$40,127	$793,338	($431,541)
$0	$805,936	$41,732	$847,668	($461,324)
$0	$862,352	$43,401	$905,753	($493,175)
$936,700	$9,906,470	$613,428	$11,456,599	($5,868,160)

were used. At an individually installed price of $600 per heater, it would cost $120,000 to install heaters in every house in the complex. Using a single pipe distribution system, the underground pipe would cost 2 times this amount plus the cost of a heat source and its necessary housing. Space for a large propane storage tank will also be required. Unfortunately, central domestic hot water is usually cost effective when combined with a central heating system. That way the heat source and piping are being purchased for other reasons and it becomes economical. Since a house unit (40 gallons) takes very little space and operates quietly, a district system which could eliminate individual tanks does not offer many advantages to each house. Therefore it is not recommended to install a district domestic hot water system at this time.

A savings potential can be implemented in each house. It is assumed that there will be an attic fan which will be thermostatically controlled to keep the roof and consequently, the whole house cool. A air to water heat exchanger can be installed along with a small circulating pump to heat the domestic water when the attic fan is running. This has the advantage of being more economical to install than a solar collector.

The analysis has demonstrated that use of district cooling is a feasible option for this project.

SECTION 5

CITY OF HARRISBURG, DISTRICT HEATING SYSTEM

The purpose of this project was the assessment of the economics of converting the Morrison Towers Building from gas fired boilers to steam district heating supplied by Harrisburg, PA Steam Works Company.

The existing Harrisburg steam district heating system is supplied from a steam plant located in close proximity to the downtown customers. The plant contains central steam boilers in combination with a diesel based cogeneration unit which supplies steam to 346 district heating customers which are serviced via a 7 mile underground piping system. The two of the current district have their own backup capacity boiler plants, therefore only 344 facilities have been considered for the possible conversion.

Many of the major downtown buildings, including the Capitol complex, are district steam customers and were originally designed and built with district heating in mind. it should be noted that steam has been supplied to the downtown community since before the turn of the century and provides heat for the majority of the City's office space.

The steam plant presently operates producing the equivalent capacity of 240,000 lbs of steam per hour and it has a maximum capacity of about 500,000 lb/hr. Therefore, there is a possibility for expansion of the system.

All district heating customers consumed about 450,000,000 lbs of steam in 1994 and the major portion of this consumption belongs to large customers having an annual steam consumption of 5,000,000 lbs and more. The district heating system has 18 customers of such a scale, one of which (HARSCO) has its own boiler as a backup.

The 17 remaining large customers present only 4.9% of the total number of the district heating customers, however they consume 72.3% of the steam generated at the plant. Therefore, each of these customers is a subject of critical importance.

The following assumptions were used:

- Annual heating & DHW load = 4,773 MMBtu/yr
- The space heating boilers use blower fans when running. The electricity cost for them is $3,508/yr.
- The DHW boilers use blower fans when running. The electricity for them is $605/yr.
- The presently installed equipment cost $69,000 to install. The equivalent steam equipment will cost $30,300.
- Boiler maintenance costs 1.5% of the boilers' capital cost.
- Burner maintenance would cost 2.4% of the boilers' capital cost.
- Steam equipment maintenance will cost $300/yr.
- All equipment has a useful life of 20 years.

Using the above parameters and an assumed seasonal efficiency of 70%, the cost for heat on a $/MMBtu basis is shown in Table 5-1.

The space heating boilers are 10 modular units totaling 345 HP. Normally, a large building would have at least a 50% backup capacity. Talking with the boiler operator, it was determined that all 10 units were required to operate during this past winter. If capital cost were to be allowed for at least one more modular boiler to give 10% backup, the price of heat would be even higher.

Attached is a flow diagram (Figure 5-1) of the necessary steam equipment. It is recommended to install a heat exchanger in the condensate tank and pass all the domestic make up water through it which is to be heated as well as the recirculated DHW. This will eliminate the need for condensate pumps. It will also eliminate the need for city water to cool down the condensate. The cost of the condensate pumps will account for the cost of the heat exchanger, so the capital cost will not increase. This will be environmentally more acceptable and will reduce the amount of steam needed to heat the DHW. A dollar amount has not been put on this steam savings.

There is no sewer charge for dumping condensate to the drain since there is no sewer meter. All sewer costs are based on the water consumption of the building, which is metered. Table 5-2 below shows the cost for heating the Morrison Towers with district steam.

Table 5-1

Cost of Individual Boiler Supplied Heat

Annual Expenditures for Morrison Towers Building	*Item or Cost Description*	*Total Annual Cost ($)*	*Unit Cost ($/MMBtu)*
HEAT LOAD			
Annual Heat Production (1000 lbs/yr)	4,773		
1. CAPITAL COMPONENT			
Capital Cost Allowance for Continuing Operations for the Next 20 years	$69,000		
Fixed Charge Rate (assuming 10% interest rate, 20 years)	0.118	$8,108	$1.70
2. MAINTENANCE/OPERATIONS (NON FUEL)			
Labor -0.25 man year @ $50,000/yr	$12,500		
Administration	Constant		
Boiler Maintenance (1.5% of capital)	$552		
Burner Maintenance (2.4% of capital)	$768		
Chemicals	None		
Water	None		
Sewer	None		
Electricity for DHW heating	$605		
Electricity for Burner Blowers	$3,508		
Insurance	unknown		
Taxes	unknown		
TOTAL NON FUEL		$17,933	$3.76
3. BOILER FUEL			
1000 cu. ft. gas @ 70% seasonal efficiency	6,550,640	$38,155	$8.00
TOTAL ANNUAL COST (1+2+3)		$64,196	$13.46

BRINJAC, KAMBIC & ASSOCIATES, INC.

CONSULTING ENGINEERS
910 N. SECOND STREET, HARRISBURG, PA 17102 • (717) 233-4502

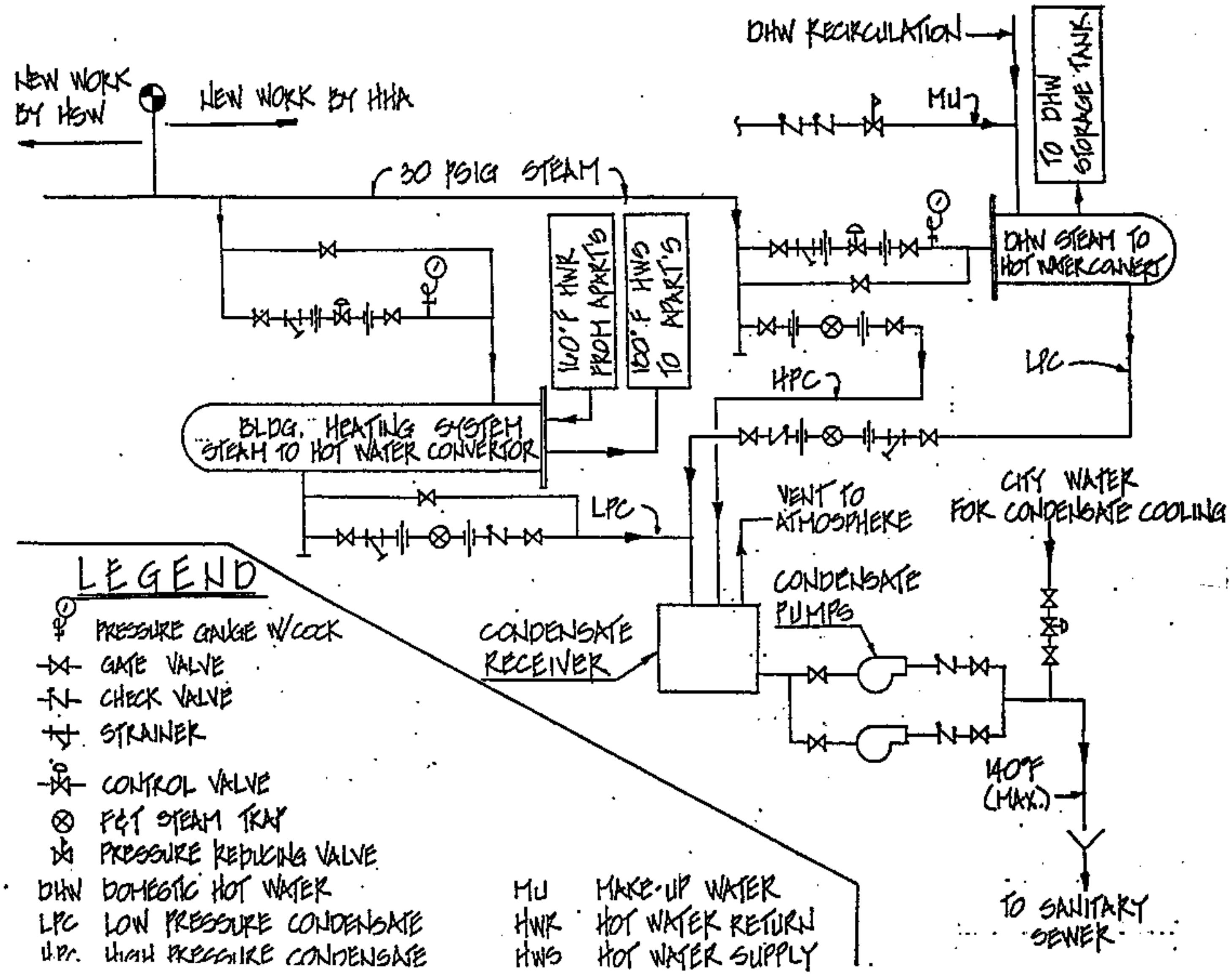


Figure 5-1

Table 5-2

Cost of Heat Supplied from Steam District Heating

Annual Expenditures for Morrison Towers Building	*Item or Cost Description*	*Total Annual Cost ($)*	*Unit Cost ($/MMBtu)*
HEAT LOAD			
Annual Heat Production (1000 lbs/yr)	4,773		
1. CAPITAL COMPONENT			
Capital Cost Allowance for Continuing Operations for the Next 20 years	$30,300		
Fixed Charge Rate (assuming 10% interest rate, 20 years)	0.118	$3,560	$0.75
2. MAINTENANCE/OPERATIONS (NON FUEL)			
Administration	Constant		
Maintenance Service - Routine	$300		
Boiler & Burner Maintenance	None		
Chemicals	None		
Water	None		
Sewer	None		
Electricity	None		
Insurance	Unknown		
Taxes	Unknown		
TOTAL NON FUEL		$300	$0.06
3. DISTRICT HEATING STEAM			
HSW -4 Tariff	4,773	$42,098	$8.82
TOTAL ANNUAL COST (1+2+3)		$45,958	$9.63

The savings when using district steam is $3.83/MMBtu. With the building's annual consumption at 4,773 MMBtu, a savings of $18,281/yr can be expected. At a conversion cost of $30,300, a payback of 1.7 years will be seen. This is well within required 15 year requirement by HUD.

CONCLUSION:

Based on the above analysis we strongly recommend to hook-up the Morrison Towers Building to the Harrisburg Steam Works district steam system.

HARRISBURG
STEAM
WORKS

Proposed Steam Rate*
Steam Used For Space Heating Entire Building and all Domestic Hot Water Heating Requirements

Harrisburg Housing Authority's Morrison Towers Building

TERM	RATE
First 10 years	$10.00 per thousand lbs.
After 10 years	Rate to be renegotiated by HSW and HHA

There is **NO** cost to Harrisburg Housing Authority to provide a service line into the new building foundation wall.

* Proposed rate is based on **HSW-4 Tariff.** This rate is subject to any changes in the Steam Cost Rate (SCR) factor and base rate factor approved by the PUC, and any PA sales tax or surcharge, and any other state or local taxes which would apply.

WPG/CMN:2/2/94

100

HARRISBURG STEAM WORKS, LTD.
100 NORTH TENTH STREET / P.O. BOX 3357 / HARRISBURG, PA 17105 / TELEPHONE (717) 234-4600 / FAX (717) 234-1375

Table 5-4

Harrisburg Steam Works Ltd.
Rate & Cost Summary for Other Utility

UGI RATE "N"
RATES IN EFFECT AS OF JAN 1, 1994

MONTHLY CUSTOMER CHARGE*

$6.302 PER CUSTOMER

COMMODITY CHARGE*

	Nov - March $/mcf	Commodity Charge Adjustmt	Take or Pay	Sub-Total	Surcharge	Total Rate "N" Commodity Charge	Rate Block MCF x Rate
First 25 mcf/month	$ 8.177	(0.058)	.143	$ 8.26	0	$ 8.26	$ 206.50
Next 475 mcf/month	7.715	(0.058)	.143	7.80	0	7.80	3,705.00
Over 500 mcf/month	6.667	(0.015)	.143	6.80	0	6.80	3,400.00

CUSTOMER SENSITIVITY INDEX FOR VARIOUS MONTHLY GAS CONSUMPTIONS

USAGE (in Mcf)	AMOUNT ($)	AVERAGE RATE ($/Mcf)	FINISHED PRODUCT COST: $/MMBTU with an ANNUAL FUEL UTILIZATION EFFICIENCY of 65%
25	$ 206.50	$ 8.26	$12.28
100	$ 791.50	$ 7.92	11.77
250	$1,961.50	$ 7.85	11.67
500	$3,911.50	$ 7.82	11.62
1000	$7,311.50	$ 7.31	10.87

* Total monthly bill equals customer charge plus commodity charge & any applicable sales tax

For comparison with steam, gas rates need to be adjusted to account for operating labor, incremental maintenance and renewal and replacement expenses, seasonal boiler efficiency and electrical auxiliary costs, boiler chemicals, water and sewer, and additional taxes and insurance.

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RATE N

GENERAL SERVICE - NON-RESIDENTIAL

AVAILABILITY

This Rate applies in the entire territory served by the Company and is available to all Customers, except residential Customers, using gas for any purpose. Service will be supplied only where the Company's facilities and the available quantity of gas are suitable to the service desired. Rate N service may not be applied to supplement or back up interruptible service under Rates TCS, IS, IL or DS, except to the extent of needs for plant protectión use. Service to the same customer under Rate N and Rates TCS, IS, IL or DS, or transfers of a customer between Rate N and Rates TCS, IS, IL or DS, shall be permitted only for good cause as determined by the Company, and subject to reasonable limitations.

MONTHLY RATE TABLE

Billing Period:	April through October	November through March	
Customer Charge:	$ 6.302 per Customer	$ 6.302 per Customer	
Plus			
Commodity Charge:			
	First 25 MCF @ $8.177 per MCF	First 25 MCF @ $8.177 per MCF	(I)
	Next 475 MCF @ $7.715 per MCF	Next 475 MCF @ $7.715 per MCF	(I)
	Over 500 MCF @ $6.530 per MCF	Over 500 MCF @ $6.667 per MCF	(I)

The Commodity Charges set forth above shall be reduced by $0.058 per MCF up to 500 MCF, and by $0.015 per MCF of usage over 500 MCF, for service rendered on and after August 1, 1985.

The State Tax Surcharge and the Surcharge for Recovery of Take-or-Pay costs as set forth in the Rules and Regulations applies to the above rates.

LATE PAYMENT CHARGE

5% on all amounts unpaid after the due date, and an additional 1-1/2% per month for each month thereafter.

MINIMUM BILLS

Where gas is used for space heating or other use directly related to weather conditions and no gas is separately metered and billed to other Customers on the premises, the bill is 3% of the average monthly use during January, February, and March billing periods of each year, as estimated by the Company.

For all others, the Customer Charge set forth above.

(I) Indicates Increase

Issued: October 28, 1993

Effective for service rendered on and after: December 1, 1993

13.5 SURCHARGE FOR RECOVERY OF TAKE-OR-PAY COSTS

Rates for each Mcf (1,000 cubic feet) of gas supplied or delivered shall be increased by the surcharge described below to recover contract reformation, buyout and buydown costs ("take-or-pay costs") billed to UGI pursuant to FERC-allowed tariffs of UGI's pipeline suppliers. These charges shall apply to all customers except a cogeneration customer under a contract that precludes recovery or retention of this charge. The applicable Gross Receipts Tax (GRT) is included in the charge for retail service.

a. Take-or-pay costs shall include a) all actual and projected Direct Billing charges, other demand charges and volumetric, throughput and commodity charges related to producer contract take-or-pay, buyout and buydown costs that are billed to the Company in conformance with Federal Energy Regulatory Commission actions and regulations and which have not been otherwise recovered by the Company, plus b) associated interest costs at 6% per annum through February 1, 1990, less c) 8% of such charges and costs which shall be absorbed immediately, less d) the first 2% of such charges absorbed as warranted by competitive conditions in Group B, which shall be absorbed as accrued.

b. Charges to recover take-or-pay costs for the current application period shall be as follows:

	Maximum Charge ($/Mcf)		
	Transportation	Retail	
Group [redacted]	0.136	[redacted]	(D)
Group B-F	0.100	0.105	
Group B-I	1.300	1.370	(I)

Group [redacted]es firm service under Rates R, GL, [redacted] NDS, CIAC, LF, LFD, and BD. Group B-F includes firm service under Rates XD, BD-L and Rate CDS. Group B-I includes interruptible service.

The charge for Group B-F is a negotiated rate not to exceed $0.10/Mcf (excluding GRT) if the Company determines in its discretion that such rate will meet competitive conditions.

The charge for Group B-I is not to exceed $1.30/Mcf (excluding GRT) if the Company determines in its discretion that such rate will meet competitive conditions. (C)

(D) Indicates Decrease
(C) Indicates Change
(I) Indicates Increase

Issued: October 1, 1992

Effective for service rendered on and after: December 1, 1992

SECTION 6

CITY OF CAMDEN DISTRICT HEATING AND COOLING SYSTEM

6.1 Introduction

In 1987 the City of Camden undertook a phase I district heating and cooling (DHC) feasibility study funded by the Department of Energy. The study focused primarily on the development of DHC using an incinerator plant, under construction, as the central energy source. prompted by the positive results of a preliminary engineering and economic assessment and the opportunity to develop DHC through cogeneration, a Phase II detailed feasibility study was conducted to further assess the prospects of DHC and to select the optimal development areas.

This study focused on two districts within the Camden City limits: the south DHC system area and the North DHC system area. Both districts are recommended from implementation by RDA, along with the direct involvement of the city. The study developed likely service scenarios for DHC using thermal load estimates for perspective customers, preliminary cost estimates for the system hardware, and anticipated O&M costs. The District Heating Advisory Group recommends the DHC development of the south district in conjunction with the waste-to-energy facility and the heating system modifications at the Camden Housing Authority complex. They also recommend the DHC development in the North District in conjunction with the waterfront development.

North Camden Project

The study proposes the use of the existing GE energy plant as a DHC central plant for the waterfront development. This plant is expected to be reliable for the next 5-10 years as the waterfront develops. At a later time, new equipment can be added to this facility or it could be phased out in favor of a new heating and cooling plant. The piping infrastructure placed in service at this time would be capable of continued service for another 40 to 50 years.

In the Camden central business district, the opportunity is available to address the waterfront development area with an initial DHC system serving the NJ State Aquarium, the planned hotel/conference center, and the initial office building development. The GE energy plant may be purchased or leased by the DHC developer. The piping system connecting the GE energy plant and waterfront development areas is estimated at about $1.5 million, while the modifications to the GE energy plant, including the installation of 800 tons of additional chiller capacity, are estimated at about $1 million.

South Camden Project

The development of cogeneration (140 MW) by GE, adjacent to the Camden Boxboard Plant and the steam sales agreement prompted other customers, such as McAndrews-Forbes and the waste-water treatment plant to consider the steam availability. With these commitments the potential for the south Camden DHC development diminished. The Branch and Roosevelt Apartments are considered for the initial development of this system using the new resource recovery facility.

The planned resource recovery facility has three HRSG capable of producing 87,000 lbs/hr of 665 psia, 750°F superheated steam from 350 tons/day of Municipal-solid-Waste (MSW). The steam is directed to 2 full condensing/extraction turbine generators capable of producing 16.85 MW each. High pressure steam from the boiler and the superheater enters at the turbine throttle, flows through a series of nozzles and blades until it is exhausted to the condenser. The controlled port is used as a bleed for constant pressure process steam, whereas the two uncontrolled ports are used primarily for in plant use of steam.

The Branch Housing consists of 279 units, totaling 181,790 sq ft, while the Roosevelt Housing consists of 268 units, totaling 275,920 sq ft. The Branch housing uses 6 boiler plants with two sectional, cast iron, low pressure boilers on each, while the Roosevelt Housing uses one central plant with 3x200hp boilers to meet their heating needs. The high unit energy consumption at these complexes is attributed to poor insulation, high heat load structure, lack of temperature controls, and lack of individual tenant responsibility for energy bills. The high maintenance and labor cost are attributed to the again underground and building piping systems, the high cost of skilled labor for boiler O & M, and the redundant costs associated with operating multiple boiler sites. The O&M costs for the heating systems in these two housing developments follows:

Branch Annual O&M Cost:	Labor: $275,000	Materials/Contractors: $190,000
Roosevelt Annual O&M Cost:	Labor: $265,000	Materials/Contractors: $180,000

The Camden Housing Authority plans to use HUD modernization funds to replace existing heating and domestic hot water systems at both housing developments. In the case of Branch Homes, the planned modification includes the installation of a wall mounted natural gas fired boiler in each dwelling unit with reconnection to existing piping, where possible. Domestic hot water heating will be provided by an electric hot water heater in each dwelling unit.

Individual utility metering is seen as desirable by the Housing Authority since tenants will be directly responsible for energy use. In the case of Roosevelt Homes, individual natural gas fired warm air furnaces are being considered for heating, and natural gas water heaters for domestic hot water. Individual energy metering typically results in a 10% -30% reduction in energy usage.

The initial development of the South Camden Community Energy Infrastructure (DEI) network involves the construction of a thermal distribution system that would link the Camden Resource Recovery Facility to the Branch Village and the Roosevelt Homes apartment complexes. The CEI network meets the coincident critical aspects of the project development in that direct benefit accrues to the customer on a comparative rate basis and secondly, the project has sufficient cash flow for financing.

The capital investment for district heating from refuse plant to housing projects is estimated at $3.2 million with an annual O&M cost at about $380,000. A 20 year life-cycle cost analysis indicates that the total project cost is about $20.5 million vs. the $30.5 million cost of the proposed individual heating systems.

This Phase II work program is designed to define and execute commitments which would initiate implementation.

- Obtain a long term commitment by a system developer/owner.
- Secure thermal energy at an attractive price from proposed cogen plant (north Camden) and from resource recovery plant (south Camden).
- Determine willingness of building owners and the community to accept energy supply from a DHC system.
- Develop consensus in showing the community that DHC development provides an attractive amenity.

6.2 Technical Assistance Recommendations

The positive results of the Phase II feasibility study provide a foundation for DHC development in the City of Camden. The DHC development approach should capitalize on the available opportunities, while considering the various constraints. Pursuing parallel development in both north and south districts not only introduces the foundation for a potentially large DHC system, but also provides redundancy in the effort, in the event unforeseen changes inhibit one of the alternatives.

Recommendations for the development of DHC in the two district follow under the associated heading.

North Camden Project

The planned waterfront development presents a unique opportunity for DHC in North Camden. The availability of district energy during the construction of this development will ensure participation. The potential for cogeneration enhances the prospects for DHC in this region. A location near the prison along with an awareness program should ease community reservations and promote acceptance. Cogeneration should be pursued with a credible developer in order to ease user/customer concerns about reliability of service. A credible developer will also enhance the prospects of attracting Rutgers University as a user.

South Camden Project

Although GE's cogeneration plant, adjacent to the Camden Boxboard Plant, reduces the potential thermal load, the available steam from the resource recovery facility and the modernization of the heating systems in the Branch and Roosevelt Homes provide an opportunity for a modest start. The allocated HUD funding for modernization may be applied towards a district heating conversion of the units. foster Wheeler's willingness to assist with the transmission pipe is an advantage that must be capitalized. Once this system is operational the enormous maintenance costs associated with the Branch and Roosevelt Homes' heating are eliminated.

Contact has been established with both entities. Meetings are being arranged with all related parties, including the Pollution control Financing Authority, in order to facilitate and direct discussion.

Cogeneration/District Heating/Cooling Project

In 1993 - 1994 the City of Camden solicited proposals from developers for a district heating/cooling system combined with a cogenration plant. One of the developers submitted a proposal for a 50 MW facility. The DHC requirements are presented in Table 6-1.

Steam Pressure Requirement - 150psig - saturated.
Minimum Peak Steam Requirement 75,000 lb/hr.

Steam will be purchased from the cogeneration plant on a temperature dependent basis to serve the City's district heating and cooling customers.

1. The developer proposal for a 50 MW cogeneration plant is based on the following terms and conditions.
   A. The City provides the developer with a firm commitment for the development of the cogeneration portion of the project.

Table 6-1
Camden DHC Project
Minimum Load Duration

Bin. Temp	Mid Pt Temp	Hours	Heating System MLBS	Cooling System MLBS	Total MLBS	Average MLBS
95/99	97	14	74	294	368	26.3
90/94	92	47	247	863	1110	23.6
85/89	87	190	998	2990	3988	21.0
80/84	82	366	1922	4797	6718	18.4
75/79	77	564	2961	5907	8868	15.7
70/74	72	806	4232	6321	10552	13.1
65/69	67	808	4242	4210	8452	10.5
55/59	57	701	8857	0	8857	12.6
50/54	52	676	11661	0	11661	17.3
45/49	47	674	014737	0		21.9
40/44	42	713	1888	0		26.5
35/39	37	784	24379	0		31.1
30/34	32	697	24891	0	24891	35.7
25/29	27	426	17179	0	17179	40.3
20/24	22	260	11685	0	11685	44.9
15/19	17	165	8177	0	8177	49.6
10/14	12	73	3955	0	3955	54.2
05/09	7	30	1764	0	1764	58.8
00/04	2	4	254	0	254	63.4
-5/-1	-3	1	68	0	68	68.0
-10/-6	-8	0	0	0	0	0.0
-15/-11	-13	0	0	0	0	0.0
		8760	167264	27344	194608	22.2

B. The City provides a firm site, with a lease option for the initial term of the project (20 years) and reasonable renewal periods, or a purchase option for said site. In either case, the site will be delivered in a certified environmentally clean conditions, meeting the State of New Jersey's "ECRA" rules and lender's requirements.

C. The City arranges, through the proper entity, to transfer to the developer the air emissions credits available due to the closing of the "Old General Electric Facility" in downtown Camden.

2. The steam price proposed to the City is \$2.50 per 1,000 lb, based on the minimum conditions set forth by the City). An additional 10,000 lb/hr of firm steam capacity, if contracts for and used when the plant goes on line, will be provided at the same cost. The steam price can be reduced by

approximately $0.50 per 1,000 lb if the city is able to provide river cooling water to the site. This is the result of station power enhancement and reducing the parasitic load required to drive cooling tower fans. The city's central chilling plant would also benefit from this cooling system in a similar fashion. It is anticipated that the developer would reimburse the city for its costs in providing this cooling water with a minimal incremental cost passed on to the chiller plant.

3. The developer would be willing to provide the city on site electric power at the PSE&G sale price, estimated to be $0.37/kwh in 1995. The backup power cost from PSE&G would be the responsibility of the city.

4. The developer proposes to provide operating services to the City central plant at cost. This would be done on a man hour basis and should be considerable less costly than otherwise available to the city.

5. The developer proposes to configure the plant using one General Electric LM 6000 dual fuel gas turbine, one HRSG, complete with dual fuel duct firing capability. One automatic extraction condensing steam turbine. The gas Turbine will employ water injection for NO_X control, along with an SCR system. As an alternative, providing the City can reasonably guarantee sufficient steam consumption, a General Electric Frame 6 gas turbine will be substituted. Dry Low NO_X combustors will be installed in this unit. The steam turbine will be cooled by a roof mounted induced draft cooling tower designed for "O" blowdown. Cation/Anion deionizers will provide boiler make up water and NO_X injection water. The LM 6000 will be fitted with inlet air cooling and heating to permit operation at peak cycle efficiency in all weather conditions. Two back up boilers will be provided to supply 75,000 lb/hr. each.

6. The preliminary heat balance provides for approximately 110,000 lbs. steam at 600 lb., 750°F from the HRSG, unfired. The steam turbine will be configured to condense the entire steam production, less auxiliary loads, and extract 75,000 lb. at 150 PSI, desuperheated, to the City central plant requirement.

7. Additional steam growth will be provided by duct firing reserve capacity in the HRSG. Additional front end capacity will be provided in the "front end" of the

steam turbine to pas the additional steam. Most likely the HRSG will be sized to provide more capacity than the incremental addition to the turbine front end. In the event that future steam load growth is substantially more than the turbine is capable of passing, the turbine will be rebladable.

8. Fuel will be provided from dedicated pre-purchased wells funded by the project. The fully allocated well head cost of the gas on a 20 year average basis is expected to be $0.95/MMBTU.

9. Back up fuel will be on site storage of # 2 diesel or jet fuel. The amount of storage is anticipated at 400,000 gallons, which is a seven day supply. This amount is based on an anticipated 4 to 5 day requirement from PSE&G. The additional 2 to 3 day volume would represent 8 to 12 days supply at the peak 75,000 lb. steam requirement of the central plant with the gas turbine located in the Appalachian Basin, providing a very high degree of deliverability.

10. A natural gas supply estimate was requested from PSE&G. Verbal information recently received indicates a cost of $1.5 million for a 16" pipeline to the site, which is included in the project estimates.

11. An electrical interconnect estimate indicates a cost of $7.5 mil for two 69 KV lines between the plant and Pensauken.

12. The expected sale price to the utility is $0.037/KWH in 1995, escalating to $0.1181 in 2015. This represents PSE&G's actual avoided cost with no levelization.

13. Preliminary construction cost estimates this project a $55 million turnkey price. This incudes the gas turbine $13 million, HRSG $4 million, steam turbine $3.5 million, switch gear, transformers $3.75 million, permitting $.75 million, engineering, construction, development, IDC and start up costs will be approximately $25 million. Contingencies of $3 million are included.

14. Conventional cogeneration project financing is planned.

The further development of the 50 MW cogenration plant demonstrated that at the present electric rate offered by PSE&G, the project is not economical.

A new solicitation for a smaller cogeneration district heating/cooling facility resulted in the award to Trigen Corporation. Trigen will concentrate on the development of a district heating/cooling system combined with an in-fence cogeneration plant.

SECTION 7

NATIONAL CONFERENCES/REGIONAL WORKSHOPS

7.1 NATIONAL HUD DISTRICT HEATING AND COOLING CONFERENCE

MAY 26-18, 1992

WASHINGTON, DC

Contract No. DU100C000016500, CN: 91-0422
TECHNICAL ASSISTANCE TO CDBG COMMUNITIES ON COMMUNITY ENERGY SYSTEMS BASED ON DISTRICT HEATING AND COOLING

AGENDA FOR PROJECT REVIEW MEETING

MAY 26, 27 AND 28, 1992

May 26, 1992 ***Function***		***Time***
Registration		8:00 am - 9:00 am
Welcome and Opening Remarks	R. Broun *(HUD, Director, Office of Environment and Energy),* R. Groberg *(HUD, Director, Energy Division),* B. Manheimer *(Deputy Director of HUD Energy Division: Program Manager for DHC)*	9:00 am - 9:45 am
Technical Assistance Available	I. Oliker *(JTC, Principal)*	9:45 am - 10:30 am
Break		10:30 am - 10:45 am
HUD Project Presentations	Camden	10:45 am - 12:00 pm
Lunch	F. Strnisa *(New York State Energy Research and Development Authority)*	12:00pm - 1:30 pm
HUD Project Presentations (continued)	Miami/Dade Jamestown	1:30 pm - 2:45 pm 2:45 pm - 4:00 pm
Concluding Remarks and Discussion	I. Oliker *(JTC, Principal),* S. Jones *(HUD, Office of Procurement and Contracts)*	4:00 pm - 4:30 pm

AGENDA FOR PROJECT REVIEW MEETING

MAY 26, 27 AND 28, 1992

May 27, 1992 ***Function***		***Time***
HUD Project Presentations (continued)	State of RI \ Providence Baltimore	8:45 am - 10:00 am 10:00 am - 11:15 am
General Discussion		11:15 am - 12:00 pm
Lunch	S. Carlson *(former Mayor of Jamestown, NY)*	12:00 pm - 1:15 pm
DOE Program Overview	R. San Martin *(DOE, Deputy Assistant Secretary for Utility Technology), (invited)* F. Collins *(DOE Program Manager for DHC)*	1:15 pm - 1:45 pm
DOE Cooling Grantees Workshop		1:45 pm - 4:30 pm
DOE Cogeneration Contractors Workshop		4:30 pm - 5:15 pm

May 28, 1992 ***Function***		***Time***
Discussion of DHC/C Action Plan	R. Zelinski *(BMF Management Services, Principal)*	8:45 am - 9:15 am
DOE -HUD Initiative	J. Millhone *(DOE, Deputy Assistant Secretary for Building Technologies)*	9:15 am - 9:45 am
Meeting Potential Government Users	P. R. Bardack *(HUD, Deputy Assistant Secretary for Economic Development)* GSA, DOD, HUD Public Housing, Postal Service, Veterans Administration M. Larkin *(Baltimore Thermal)* J. Fiegel *(IDHCA)*	9:45 am - 11:30 am
What's New on Energy in Congress	C. Werner *(Program Director, Environment and Energy Study Institute)*	11:30 am - 12:00 pm
Concluding Remarks	Participants	12:00 pm - 12:30 pm

Project Descriptions

HUD DISTRICT HEATING AND COOLING CONFERENCE
May 26-28, 1992

Project Location:	Baltimore, MD
Project Name:	Distribution Line extension to Broadway Towers
Grant Origination:	U.S. HUD
Grantee (Primary Contact):	Bruno Rudaitis (301) 396-8361 Planner Dept of Planning, City of Baltimore, MD
Primary Project Objectives:	*Develop Design Documentation for a Steam Distribution Line to Broadway Towers, a 422 unit public housing project.* Baltimore Thermal recently purchased the Central Ave plant which supplied steam to 5 public housing projects. As part of the sale, 3 additional public housing projects are to be connected to the plant. The 3 projects include Monument East, LaTrobe Housing and Broadway Towers. Estimated 1200 ft of distribution piping is required.
Consultant Company Name:	Baltimore Thermal Energy Corp
Consultant Contact Person:	G. Michael Larkin, Jr. (410) 625-2222

Project Location:	Camden, NJ
Project Name:	Camden District Heating and Cooling Project: Design Development Project
Grant Origination:	U.S. HUD
Grantee (Primary Contact):	Frederick H. Martin, Jr. (609) 757-7680 Director of Dept of Utilities Camden, NJ
Primary Project Objectives:	*Assess district heating and cooling opportunities in two major areas in Camden* The goal of the project is to further promote development of a district heating and cooling system for two sites within Camden referred to as the North and South District. The North District project (near the waterfront) seeks cooperation with the City, Cooper's Ferry Development Association and users such as Campbell, GE Aerospace Rutger's University, N.J. State Aquarium and the old RCA facility. Several options are available including seeking a cogeneration developer. The second site involves assistance to the Camden Housing Authority in developing a district heating system connected to the Camden Resource Recovery Plant.
Consultant Company Name:	RDA Engineering Inc.
Consultant Contact Person:	David Wade (404) 421-0870

Project Descriptions

HUD DISTRICT HEATING AND COOLING CONFERENCE
May 26-28, 1992

Project Location:	Jamestown, NY
Project Name:	District Heating Expansion in Jamestown
Grant Origination:	U.S. HUD
Grantee (Primary Contact):	Douglas V. Champ (716) 483-7582 District Heating Manager City of Jamestown
Primary Project Objectives:	*Expansion of District Heating to Include Publicly Assisted Elderly Housing* The goal of the project is to further expand the district heating system to new customers including public housing. Coupled with this expansion effort are the opportunities to implement demand-side management options and economic development strategies.
Consultant Company Name:	Joseph Technology Corporation
Consultant Contact Person:	Dr. Ishai Oliker, PE (201) 573-0529

Project Location:	Miami, FL
Project Name:	Justice Center District Cooling System
Grant Origination:	U.S. HUD
Grantee (Primary Contact):	Don W. Youatt (305) 375-3499 Facilities Engineer Metro-Dade County
Primary Project Objectives:	*Assess district cooling technologies for energy efficient design at the Justice Center* The goal of the project is to further develop design concepts as it regards construction of a central cooling plant for the Justice Center complex. Initial studies endorsed district cooling vs distributed cooling plants recognizing first cost and maintenance savings. This study shall provide detailed analyses of alternative cooling sources including well water, cooling loop temperature, power selection optimization, and environmental impact.
Consultant Company Name:	Smith Korach
Consultant Contact Person:	Avinash Gupta

Project Descriptions

HUD DISTRICT HEATING AND COOLING CONFERENCE
May 26-28, 1992

Project Location:	Providence, RI
Project Name:	Providence District Cooling and Heating Project
Grant Origination:	U.S. HUD
Grantee (Primary Contact):	Janice McClanaghan (401) 277-3370 Energy Programs Manager Governor's Office of Energy, State of Rhode Island
Primary Project Objectives:	*Develop a District Cooling and Heating Project in downtown Providence* The goal of the project is to provide efficient, cost effective and environmentally aware energy to potential customers of a system in downtown Providence. The project shall assess the opportunities for implementing a CES/DHC through design, marketing and financing tasks. Several project areas identified include the Foundry, Civic Center/Convention Center, State House and adjacent State buildings, Providence Place, Capital Center Project and downtown business district.
Consultant Company Name:	Joseph Technology Corporation
Consultant Contact Person:	Dr. Ishai Oliker, PE (201) 573-0529

Attendance List

HUD DISTRICT HEATING AND COOLING CONFERENCE
May 26 - 28, 1992

	Name		Title	Affiliation / Company	Address				Telephone	Fax
1	David	Anderson	President	The Stamford Partnership	5 Landmark Square	Stamford	CT	06901	203-325-4461	
2	Charles R.	Ashmore	Utilities Officer	U.S. HUD Public & Indian Housing, Room 4124	451 7th Street, SW	Washington	DC	20410	202-708-4703	
3	Jerry	Bohan	General Manager, Field Maintenance Support	U.S. Postal Service HQS	475 L'Enfant Plaza W. SW	Washington	DC	20260	202-268-2582	
4	Steven B.	Carlson	former Mayor of Jamestown		27 Ellis Ave	Jamestown	NY	14701	716-487-9072	716-664-3470
5	Douglas V.	Champ	District Heating Manager	City of Jamestown	Municipal Bldg, P.O. Box 700	Jamestown	NY	14702	716-483-7582	716-483-7705
6	William L.	Chapman	Senior Program Monitor	Governor's Energy Office, State of Rhode Island	275 Westminster Street	Providence	RI	02903	401-277-3370	401-277-1260
7	Floyd J.	Collins	DHC Program Manager	U.S. DOE Utility Systems Division	Forrestal Bldg Room F-064, 1000 Independence Ave, SW	Washington	DC	20585	202-586-9191	202-586-8134
8	John T.	Comerfory	Director, Financial Management Division	U.S. HUD	451 7th Street, SW	Washington	DC	20410	202-708-1872	
9	John	Fiegel	Deputy Executive Director	IDHCA	1101 Connecticut Ave, NW, Suite 700	Washington	DC	20036	202-429-5111	202-429-5113
10	Mark	Finks	Energy Management Specialist	U.S. HUD Energy Division	451 7th Street, SW	Washington	DC	20410	202-708-2504	202-708-3363
11	Ernie	Freeman	Senior Program Manager	U.S. DOE CE-421	1000 Independence Ave, SW	Washington	DC	20585	202-586-9192	202-586-1628
12	Robert	Groberg	Director, Energy Division	U.S. HUD Room 7244	451 7th Street, SW	Washington	DC	20410	202-708-2504	202-708-3363
13	John	Iaconis	Chief, Maintenance	U.S. General Services Administration	PMF - Room 4321	Washington	DC	20405	202-501-0429	202-501-3296
14	Bill	Johnson	Assistant Director	Dade County Dept of Development and Facilities Management	111 NW 1st Street Suite 2460	Miami	FL	33128	305-375-4513	305-375-4656
15	Sam	Jones	Contract Administrator	U.S. HUD	451 7th Street, SW	Washington	DC	20410	202-708-1162	202-401-2032
16	G. Michael	Larkin, Jr.	Executive Vice President	Baltimore Thermal Energy Corp	1400 Ridgely Street	Baltimore	MD	21230	410-625-2222	410-332-7398
17	Bill	Major	Project Manager	Joseph Technology Corporation	186 Broadway	Woodcliff Lake	NJ	7675	201-573-0529	201-573-9060
18	Bernie	Manheimer	Deputy Director, Energy Division: DHC Program Manager	U.S. HUD Energy Division	451 7th Street, SW	Washington	DC	20410	202-708-2504	202-708-3363
19	Fredrick H.	Martin, Jr.	Director	Dept of Utilities, City of Camden	Camden City Hall, Room 419	Camden	NJ	08101	609-757-7680	609-541-9668

Attendance List

HUD DISTRICT HEATING AND COOLING CONFERENCE
May 26 - 28, 1992

	Name		Title	Affiliation / Company	Address				Telephone	Fax
20	Janice	McClanaghan	Energy Programs Manager	Governor's Energy Office, State of Rhode Island	275 Westminster Street	Providence	RI	02903	401-277-3370	401-277-1260
21	Bernie	McShare	Program Officer	U.S. HUD, Room 7244	451 7th Street, SW	Washington	DC	20410	202-708-2504	
22	Bill	Murphy	Energy Conservation Administrator	City of Phoenix	2631 South 22nd Ave	Phoenix	AZ	85009	602-262-7897	
23	Ishai	Oliker	Principal	Joseph Technology Corporation	188 Broadway	Woodcliff Lake	NJ	7675	201-573-0529	201-573-9060
24	Keith D.	Patch	Senior Engineer	TECOGEN	P.O. Box 9046	Waltham	MA	02254	617-622-1022	617-622-1025
25	Clinton W.	Phillips	Engineering Consultant	Clinton W. Phillips, PE	4221 Briars Road	Olney	MD	20832-1814	301-774-6057	301-774-0949
26	Bill	Powell	Program Manager	U.S. Postal Service	475 L'Enfant Plaza W. SW	Washington	DC	20260-6414	202-268-3886	202-268-4495
27	Lee Ann M.	Profera	Administrative Analyst	Dept of Utilities, City of Camden	Camden City Hall, Room 419	Camden	NJ	08101	609-757-7226	609-541-9668
28	Bruno	Rudaitis	Planner	Dept of Planning, City of Baltimore	417 E. Fayette Street	Baltimore	MD	21202	301-396-8361	
29	Art	Spiegel	Mechanical Engineer	Naval Facilities Code 165213	200 Stovall Street	Alexandria	VA	22332	703-325-0363	703-325-6904
30	Fred	Strinsa	Manager	New York State Research and Development Authority	2 Empire State Plaza	Albany	NY	12223	518-465-6251	
31	William	Tayler	Head, Utilities Engineering Branch	DOD/Naval Facilities Engineering Command	200 Stovall Street	Alexandria	VA	22332	703-325-0362	703-325-6904
32	Bill	Thorson	Director, Maintenance and Supply	U.S. HUD PI-H	451 7th Street, SW	Washington	DC	20410	202-708-4703	
33	David	Wade	President	RDA Engineering, Inc	134 South Ave	Marietta	GA	30060	404-421-0870	404-421-0885
34	Carol	Werner	Director, Energy & Climate	Environmental & Energy Study Institute	122 C Street, NW, Suite 700	Washington	DC	20001	202-628-1400	202-628-1825
35	Don W.	Youatt	Facilities Engineer DDFM	Metro-Dade County	111 NW 1st Street Suite 2460	Miami	FL	33128	305-375-3499	305-375-1125
36	Richard	Zelinsky	Principal	Business Management Services	12778 Lost Creek Ct	Manassas	VA	22111	703-590-1835	

7.2 NATIONAL HUD DISTRICT HEATING AND COOLING CONFERENCE

JUNE 19-23, 1993

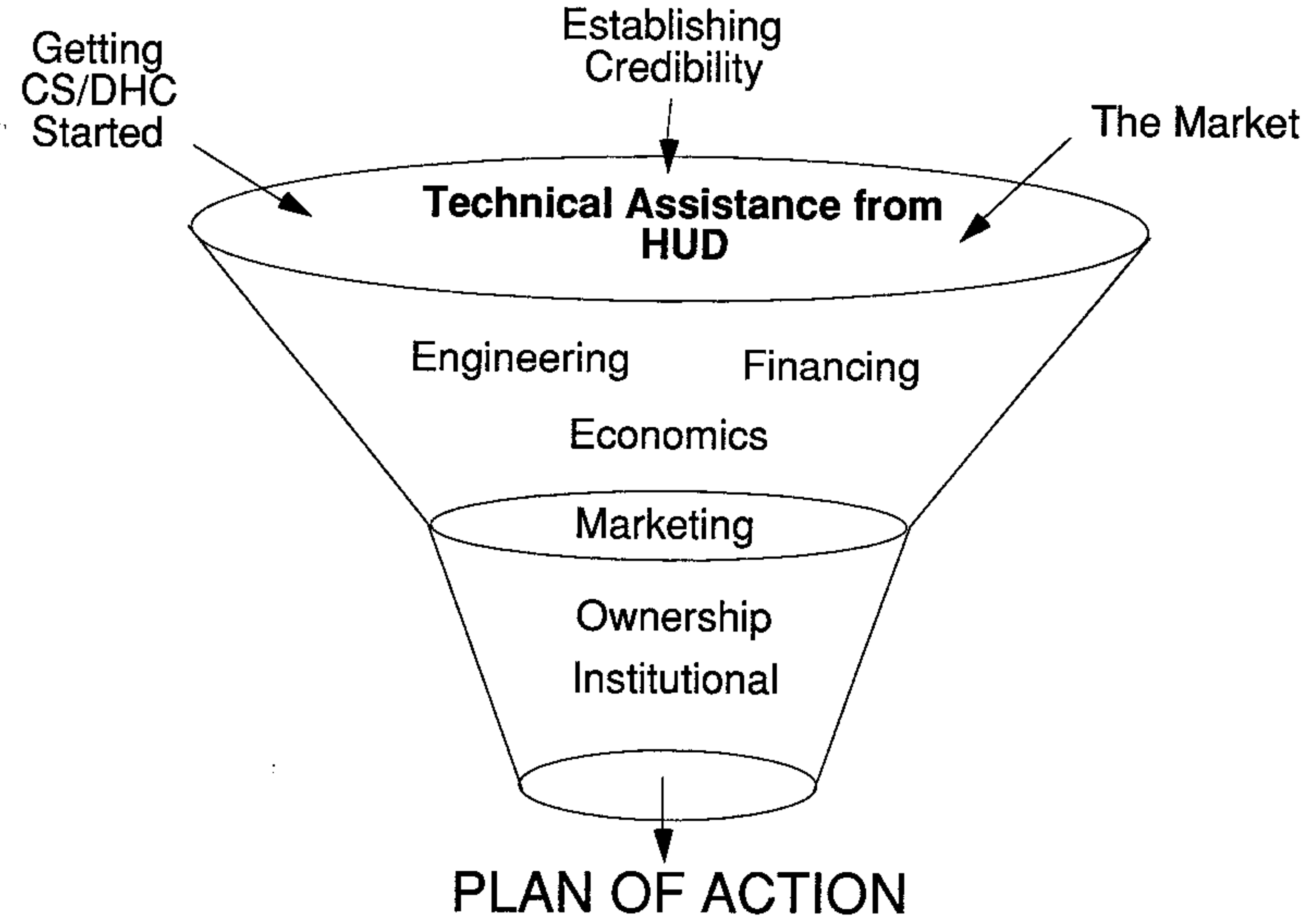
HARRISBURG, PENNSYLVANIA

Agenda for the
HUD District Heating and Cooling Project Sessions
at the 1993 IDHCA Conference

June 23 and 24, 1993

Function	Presentations	Time
Session Moderators:	1. Michael Larkin, Jr, Baltimore Thermal Energy Corporation	9:00 - 9:45 am
Bernard Manheimer, Deputy Director, HUD Energy Division	2. Frederic H. Martin, Jr. City of Camden, NJ	9:45 - 10:45 am
Ishai Oliker, Principal, Joseph Technology Corporation, Inc.	3. Douglas V. Champ City of Jamestown	10:30 - 11:15 am
	4. Don W. Youatt Metro-Dade County, Miami Florida	11:15 - 12:00
	5. Janice McClanaghan Governor's Office of Housing, Energy and Intergovernmental Relations	1:30 - 2:15 pm

Advancing CES/DHC Through Technical Assistance for Fast and Effective Results



Technical Assistance Program

- Cost Control Measure
- Provide Experienced Assistance
- Facilitate Project Activity
- Full Range of Subjects

Applying Technical Assistance

- Become Acquainted with Community Project
  - Progress to Date
  - Review Past Work
  - Potential Suppliers and End-Users (Market)
- Identify Areas Requiring TA
  - Ownership / Institutional
  - Marketing
  - Economics / Financing
  - Engineering

Tasks and Methods

1. Problem Identification for Each Site
2. Develop TA Work Plan
3. Implement TA Work Plan
4. Follow-Up Assistance
5. Evaluation of Program

The TA Work Plan

- Identify Needs, Issues, Problems
- Personnel / Expertise Requirements
- Task Descriptions
- Project Schedule and Milestones

TA Implementation

- Site Visits
- Heat Plan / Heat Map Computer Software
- Pepare TA Response Report
  - Findings
  - Planned Solutions
  - Further Action
- Exit Interview
- Follow-Up Assistance

7.3 NATIONAL HUD DISTRICT HEATING AND COOLING CONFERENCE

JUNE 19 - 20, 1994

SEATTLE WASHINGTON

Agenda
National HUD District Heating and Cooling Conference

June 19-23, 1994

Seattle, Washington

Function	Presentations	Time
Session Moderators:	1. Mr. Douglas V. Champ District Heating Manager Board of Public Utilities City of Jamestown	10:45-11:15 am
Bernard Manheimer, Deputy Director, HUD Energy Division		
Ishai Oliker, Principal, Joseph Technology Corporation, Inc.	2. Don W. Youatt Metro-Dade County, Miami Florida	11:15 - 11:45 am
	3. Michael Larkin, Jr. Baltimore Thermal Energy Corporation	1:15 - 1:35 pm
	4. Elliott G. Jennings City of Camden, New Jersey	1:40 - 2:00pm
	5. Dr. I. Oliker For the City of Providence, Rhode Island	2:05 - 2:30 pm

JOSEPH TECHNOLOGY CORPORATION, INC.

188 Broadway, Woodcliff Lake, New Jersey 07675

Phone: (201) 573-0529 Fax: (201) 573-9060

April 4, 1994

Mr. Don Yourtt
Project Manager
Department of Development and Facilities Management
111 N.W. First Street
Miami, FL 33128-1914

Subject: ***IDHCA Conference, June 19, 20, 1994***
Seattle, Washington

Dear Yourtt:

Mr. Bernard Manheimer, Deputy Director of HUD Energy Division, Program Manager for DHC, cordially invites you to attend a session on district heating and cooling development in your city to be held at the annual IDHCA Conference on June 20, 1994 (10:45 to 11:45 a.m. and 1:30 to 2:30 p.m.). You are invited to discuss the work-in-progress and the strategy for developing DHC in your community. No papers are expected, but a viewgraph presentation to illustrate the more important aspects concerning DHC in your community would be helpful. You may charge your expenses to the project and if funds are available you may bring a second person to the conference.

In addition on June 19, 1994 (9:00 a.m.), we are planning to have a separate session just for members of the HUD team to discuss all problem issues and barriers to development of DHC in your city and also review your June 20th presentation.

Please let us know who will be attending and if you have any questions, please do not hesitate to call. You should make your own reservations for accommodations at the Sheraton Seattle Hotel and Towers, please coordinate the hotel stay and rate with IDHCA at 202-429-5111.

Sincerely,

Dr. Ishai Oliker, P.E.
Principal, Joseph Technology

on behalf of: Bernard Manheimer
Deputy Director of HUD Energy Division
Program Manager for DHC

JTC

JOSEPH TECHNOLOGY CORPORATION, INC.

188 Broadway, Woodcliff Lake, New Jersey 07675

Phone: (201) 573-0529

Fax: (201) 573-9060

April 4, 1994

Ms. Janice McClanaghan
Energy Program Manager
Governor's Office of Housing, Energy and
Intergovernmental Relations
State of Rhode Island
275 Westminster Street
Providence, RI 02903

Subject: ***IDHCA Conference, June 19, 20, 1994***
Seattle, Washington

Dear Ms. McClanaghan:

Mr. Bernard Manheimer, Deputy Director of HUD Energy Division, Program Manager for DHC, cordially invites you to attend a session on district heating and cooling development in your city to be held at the annual IDHCA Conference on June 20, 1994 (10:45 to 11:45 a.m. and 1:30 to 2:30 p.m.). You are invited to discuss the work-in-progress and the strategy for developing DHC in your community. No papers are expected, but a viewgraph presentation to illustrate the more important aspects concerning DHC in your community would be helpful. You may charge your expenses to the project and if funds are available you may bring a second person to the conference.

In addition on June 19, 1994 (9:00 a.m.), we are planning to have a separate session just for members of the HUD team to discuss all problem issues and barriers to development of DHC in your city and also review your June 20th presentation.

Please let us know who will be attending and if you have any questions, please do not hesitate to call. You should make your own reservations for accommodations at the Sheraton Seattle Hotel and Towers, please coordinate the hotel stay and rate with IDHCA at 202-429-5111.

Sincerely,

Dr. Ishai Oliker, P.E.
Principal, Joseph Technology

on behalf of: Bernard Manheimer
Deputy Director of HUD Energy Division
Program Manager for DHC

JTC

JOSEPH TECHNOLOGY CORPORATION, INC.

188 Broadway, Woodcliff Lake, New Jersey 07675

Phone: (201) 573-0529 Fax: (201) 573-9060

April 4, 1994

Mr. Douglas V. Champ
District Heating Manager
Board of Public Utilities
City of Jamestown
P.O. Box 700
Jamestown, NY 14702-0700

Subject: ***IDHCA Conference, June 19, 20, 1994***
Seattle, Washington

Dear Mr. Champ:

Mr. Bernard Manheimer, Deputy Director of HUD Energy Division, Program Manager for DHC, cordially invites you to attend a session on district heating and cooling development in your city to be held at the annual IDHCA Conference on June 20, 1994 (10:45 to 11:45 a.m. and 1:30 to 2:30 p.m.). You are invited to discuss the work-in-progress and the strategy for developing DHC in your community. No papers are expected, but a viewgraph presentation to illustrate the more important aspects concerning DHC in your community would be helpful. You may charge your expenses to the project and if funds are available you may bring a second person to the conference.

In addition on June 19, 1994 (9:00 a.m.), we are planning to have a separate session just for members of the HUD team to discuss all problem issues and barriers to development of DHC in your city and also review your June 20th presentation.

Please let us know who will be attending and if you have any questions, please do not hesitate to call. You should make your own reservations for accommodations at the Sheraton Seattle Hotel and Towers, please coordinate the hotel stay and rate with IDHCA at 202-429-5111.

Sincerely,

Dr. Ishai Oliker, P.E.
Principal, Joseph Technology

on behalf of: Bernard Manheimer
Deputy Director of HUD Energy Division
Program Manager for DHC

the City of Jamestown to control the major sources of energy: electricity and heating. The municipal control of these energy sources is used as an economic development tool by the city to attract new business.

The future of DH is Jamestown appears very attractive considering the development of a system with twice the capacity of the present load. The present 13 MWt peak load can be expanded to match the available 26 MWt capacity with minimal capital investment. Any system growth beyond the existing customer base is expected to enhance the economic operation of the system.

JTC

JOSEPH TECHNOLOGY CORPORATION, INC.

188 Broadway, Woodcliff Lake, New Jersey 07675

Phone: (201) 573-0529 Fax: (201) 573-9060

April 4, 1994

Mr. Frederick H. Martin, Jr.
Director of Utilities
City of Camden
Room 419, City Hall
Camden, NJ 08101

Subject: ***IDHCA Conference, June 19, 20, 1994***
Seattle, Washington

Dear Mr. Martin:

Mr. Bernard Manheimer, Deputy Director of HUD Energy Division, Program Manager for DHC, cordially invites you to attend a session on district heating and cooling development in your city to be held at the annual IDHCA Conference on June 20, 1994 (10:45 to 11:45 a.m. and 1:30 to 2:30 p.m.). You are invited to discuss the work-in-progress and the strategy for developing DHC in your community. No papers are expected, but a viewgraph presentation to illustrate the more important aspects concerning DHC in your community would be helpful. You may charge your expenses to the project and if funds are available you may bring a second person to the conference.

In addition on June 19, 1994 (9:00 a.m.), we are planning to have a separate session just for members of the HUD team to discuss all problem issues and barriers to development of DHC in your city and also review your June 20th presentation.

Please let us know who will be attending and if you have any questions, please do not hesitate to call. You should make your own reservations for accommodations at the Sheraton Seattle Hotel and Towers, please coordinate the hotel stay and rate with IDHCA at 202-429-5111.

Sincerely,

Dr. Ishai Oliker, P.E.
Principal, Joseph Technology

on behalf of: Bernard Manheimer
Deputy Director of HUD Energy Division
Program Manager for DHC

JTC

JOSEPH TECHNOLOGY CORPORATION, INC.

188 Broadway, Woodcliff Lake, New Jersey 07675

Phone: (201) 573-0529 *Fax: (201) 573-9060*

April 4, 1994

Mr. Bruno Rudaitis
Department of Planning
City of Baltimore
8th Floor
417 E. Fayette Street
Baltimore, MD 21202-3416

Subject: ***IDHCA Conference, June 19, 20, 1994***
Seattle, Washington

Dear Mr. Rudaitis:

Mr. Bernard Manheimer, Deputy Director of HUD Energy Division, Program Manager for DHC, cordially invites you to attend a session on district heating and cooling development in your city to be held at the annual IDHCA Conference on June 20, 1994 (10:45 to 11:45 a.m. and 1:30 to 2:30 p.m.). You are invited to discuss the work-in-progress and the strategy for developing DHC in your community. No papers are expected, but a viewgraph presentation to illustrate the more important aspects concerning DHC in your community would be helpful. You may charge your expenses to the project and if funds are available you may bring a second person to the conference.

In addition on June 19, 1994 (9:00 a.m.), we are planning to have a separate session just for members of the HUD team to discuss all problem issues and barriers to development of DHC in your city and also review your June 20th presentation.

Please let us know who will be attending and if you have any questions, please do not hesitate to call. You should make your own reservations for accommodations at the Sheraton Seattle Hotel and Towers, please coordinate the hotel stay and rate with IDHCA at 202-429-5111.

Sincerely,

Dr. Ishai Oliker, P.E.
Principal, Joseph Technology

on behalf of: Bernard Manheimer
Deputy Director of HUD Energy Division
Program Manager for DHC

7.4 Regional Workshop

Camden, New Jersey

October, 1993

District Cooling Development
in
Camden, New Jersey

by

Frederick H. Martin - Director of Utilities - City of Camden
LeeAnn Profera - District Heating Project Manager - City of Camden
David W. Wade, P.E. - President, RDA Engineering, Inc.

INTRODUCTION

The City of Camden is located across the Delaware River just east of Philadelphia. In the 1940's Camden was a center for ship building and related industries. Campbell's Soup Company, the Victor Talking Machine Company and Esterbrook Pen Company were founded in Camden and grew to become prominent corporate citizens. The City's favorite son-Walt Whitman, was inspired by the activity of Camden to write:

"I dream'd in a dream a city invincible
to the attacks of the whole rest of the earth."

Unfortunately, today's images of Camden are those of poverty, blight and urban decay. A January, 1992 Time Magazine article makes the following observation: "To wander through its neighborhoods is to wonder what America should be doing with towns like this, towns that cry out for help yet seem beyond saving."

Despite its proximity to Philadelphia, Camden's economy has experienced a steady decline over the past twenty years. In the early 1980s, the Brookings Institute identified Camden as one of the ten most distressed communities in the nation. Currently, Camden receives over $50 million a year in State aid to subsidize its tax revenues. In fact, over sixty percent of the city's residents receive state or federal support supplements.

Population in the city declined during the 60's, 70's and 80's to approximately 85,000 residents currently. Camden is the hole in the donut of the greater Camden County area which has a population of over 500,000 people.

Camden's problems have not gone unnoticed. Beginning in the 1970's the City became a target for investments by federal, state, county and local governments in an effort to leverage private investment and halt the City's economic decline. These public dollars have been invested in Camden for infrastructure repair, job creation and public development activity.

In recent years the cornerstone of Camden's Central Business District redevelopment has been its waterfront. Investors have pulled together roughly a quarter of a billion dollars that will bring to the Delaware waterfront the headquarters for GE Aerospace, plus a hotel, waterfront office park, the nation's second largest aquarium and an office tower to contain the world headquarters of Campbell's Soup Company. These ambitious projects are being coordinated under the direction of the Cooper's Ferry Development Corporation, a partnership of local government and business interests.

The new State of New Jersey Aquarium opened on Camden's Waterfront in February, and thus far it is operating at close to three times the projected visitor load. GE Aerospace has chosen to relocate its electronic laboratories and manufacturing in Camden. The initial G. E. manufacturing facility will be occupied in the fall of 1992. Campbell's Soup Corporation has broken ground for their new world headquarters, as the first building in a waterfront office park.

OPPORTUNITIES FOR DISTRICT HEATING AND COOLING

With all of Camden's problems, an observer must ask "Why consider District Heating and Cooling?" The answer is found in the City's approach to the future - rebuild from the ground up.

When energy price forecasts looked grim during the early 80's, the Mayor of Camden - Melvin R. Primas, Jr. and the City's Director of Utilities, Frederick H. Martin, identified district heating as a desirable infrastructure to compliment Camden's rebuilding effort. District heat (and cooling) was viewed as a service that could attract new businesses with stable energy costs and serve existing city buildings in an energy efficient manner. A DHC system could also provide much needed environmental benefits to the Camden area.

Camden's desire to rebuild with the most efficient and environmentally acceptable energy system was initially helped by a U.S. Department of Energy, District Heating and Cooling Program Phase I, Cooperative Agreement. Under this program the U.S. DOE provided grant funds to assist the city in evaluating the use of district heating and cooling. The DHC assessment was completed in December of 1987 and was the first in a series of complimentary actions by the City, County and Camden community leading to the planned implementation of two district energy systems serving different areas of the city.

DHC FEASIBILITY AND PLANNING

Planning and feasibility evaluation of a district energy system is like any capital intensive business venture. Factors affecting the desirability of DHC as a business include: capital costs, financing rates, expected market, and required return on investment. Since today's development of district energy systems is similar to land development projects, feasibility is scrutinized closely by investors, lenders and the potential customers.

Experience with district heating and cooling development in Camden has verified some of the inherent difficulties encountered with implementing this technology in the United States:

1. Today's energy market is extremely competitive. The supply of heating, cooling, and electric energy to buildings and industries is characterized by aggressive pricing, special rate structures which encourage

consumption at "off-peak" times, incentives in the form of rebates or credits due to regional market concerns and a general consumer attitude that energy prices and availability are insignificant business concerns.

2. Development of a DHC system is site and customer specific. New district systems must be designed around individual customer energy needs and are dependent on new building construction and growth projections. Thus, when uncertainty prevails with regard to new building construction or industrial production requirements, a significant degree of risk is introduced into development of such a capital intensive venture.

3. Much of the initial cost of district cooling is dedicated to infrastructure development which will be utilized in the future. This places an especially heavy burden on new district cooling ventures which bear the costs of oversized piping, initial central energy plant development, and the planning, engineering and legal fees, etc. associated with establishing a district cooling utility. For a given service area these costs may easily be 100 times greater than the incremental cost of an established natural gas or electric utility serving the same customers.

4. Pursuit of a district energy system is predicated on a committed system developer. The developer must be willing to make investments for long-term community benefit, accept below-market rates of return and be willing to meet the service requirements of specific customers in the time they require. Timing is crucial since most U.S. district systems are commissioned in response to new building construction in the potential service area. Typically, these projects present a tight construction schedule with no tolerance for utility delays.

Needless to say, the foregoing concerns have all been encountered during the five year study and development period of the Camden Project.

CAMDEN'S DEVELOPMENT PROCESS

The driving force for Camden's district cooling development efforts have been the direct interest of the City's Utilities Department Director, elected officials and a community desire for redevelopment and long-term benefits. The City's interests have been supported by the availability of U.S. Department of Energy and U.S. Department of Housing and Urban Development District Energy Programs which provided matching funds to assemble the technical resources for project feasibility analysis and community education. With Camden's limited financial means it is doubtful that district heating and cooling would have been aggressively pursued without financial help from federally funded programs. It should also be noted that the State of New Jersey provided supplemental funding for feasibility assessments pertaining to Rutgers University and has been supportive throughout the development process in Camden's district system planning.

Figure No. 1 illustrates the chronology of Camden's district heating and cooling development efforts. The process began in 1986 with an initial Phase I assessment funded by the U.S. Department of Energy. This project evaluated potential for development of district heating in conjunction with a waste-to-energy facility constructed in the southern portion of the city. A supplemental study funded by the State of New Jersey evaluated the potential for district heating and cooling system development in the downtown of Camden which would serve a regional hospital, Rutgers University and several city/county buildings. This study was conducted as a result of a planned 130 megawatt combined-cycle cogeneration plant at the Campbell Soup Production Plant in downtown Camden. The results of the state funded study indicated DHC development would be attractive in conjunction with the proposed cogen project.

A U.S. Department of Housing and Urban Development Cooperative Agreement allowed further evaluation of the downtown system beginning in mid 1989 through 1990. During the evaluation process, however, the Campbell Soup Production Plant was closed and the planned cogen facility abandoned. The recessionary period of 1989-1990 extended the time frame for development of waterfront offices, hotel, and conference facilities. Construction and funding delays also caused the New Jersey State Aquarium to be finished behind the original development schedule. The results of the HUD funded program indicated that a district energy system could be desirable for waterfront buildings but, timing of projects, low office building demand and lack of a committed long-term DHC developer would make district heating and cooling implementation extremely difficult.

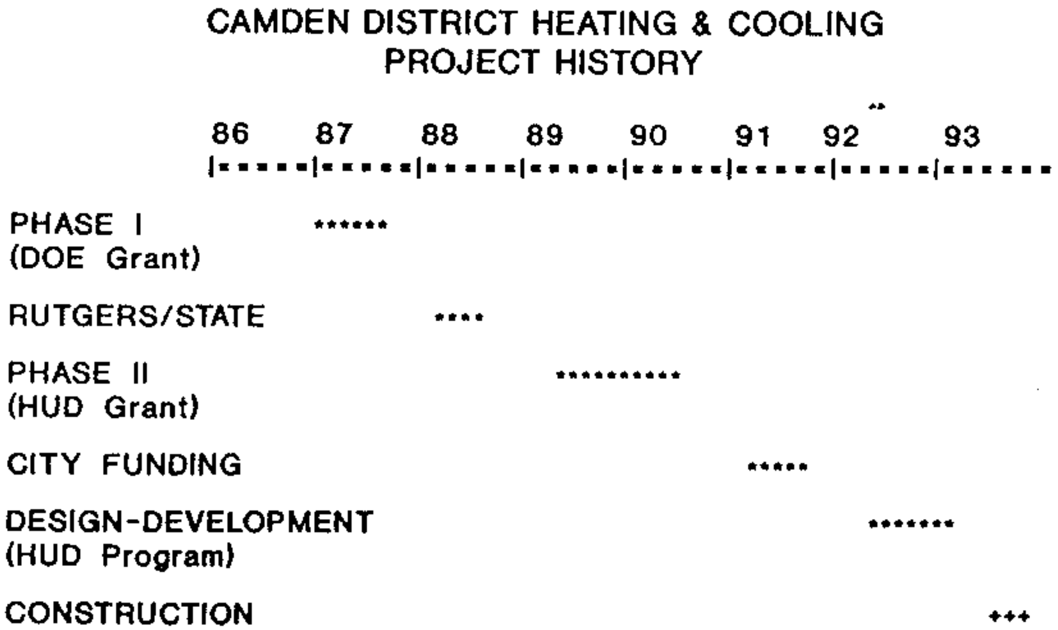


Figure 1

In the first quarter of 1991 the State of New Jersey, Camden County, and the City of Camden entered into an agreement with General Electric Aerospace Corporation to retain this important employer in the Camden Central Business District. The agreement resulted in the fast track construction of a 250,000 square foot manufacturing building and 350,000 square foot engineering office center on the site of the abandoned Campbell's Soup Production Plant. As a result, the City Department of Utilities funded interim work efforts by RDA Engineering, Inc., the DHC project consultant, to work with the development team for district heating and cooling. At the same time Rutgers University decided to pursue construction of a small on-campus cogeneration system using a state energy grant. The city, RDA Engineering, Inc., and Rutgers University began exploring alternatives to small-scale cogeneration by using a larger district heating and cooling system to serve the Rutgers Campus and surrounding waterfront development area.

Early in 1992 the City entered into a second cooperative agreement with the U.S. Department of Housing and Urban Development to pursue design development of a district heating and cooling system serving the waterfront area, newly constructed GE Aerospace buildings, the planned rehabilitation of the RCA Manufacturing Complex (formerly occupied by GE Aerospace), and Rutgers University. This work is on-going with scheduled completion early in 1993.

Throughout the process, significant efforts have been expended evaluating various system configurations for district heating and cooling in response to the changing waterfront development climate and the volatile construction schedules dictated by market conditions. Much of this effort has been expended to educate consumers, community leaders, and the various community groups which would be affected by district heating and cogeneration development. Work efforts have included: detailed building surveys, preparation of special marketing assessments for target customers, evaluations of Rutgers University energy requirements, individual meetings with project developers and tenants, meetings with the N.J. Department of Energy, and public meetings with local community groups. As a result of community involvement a consensus

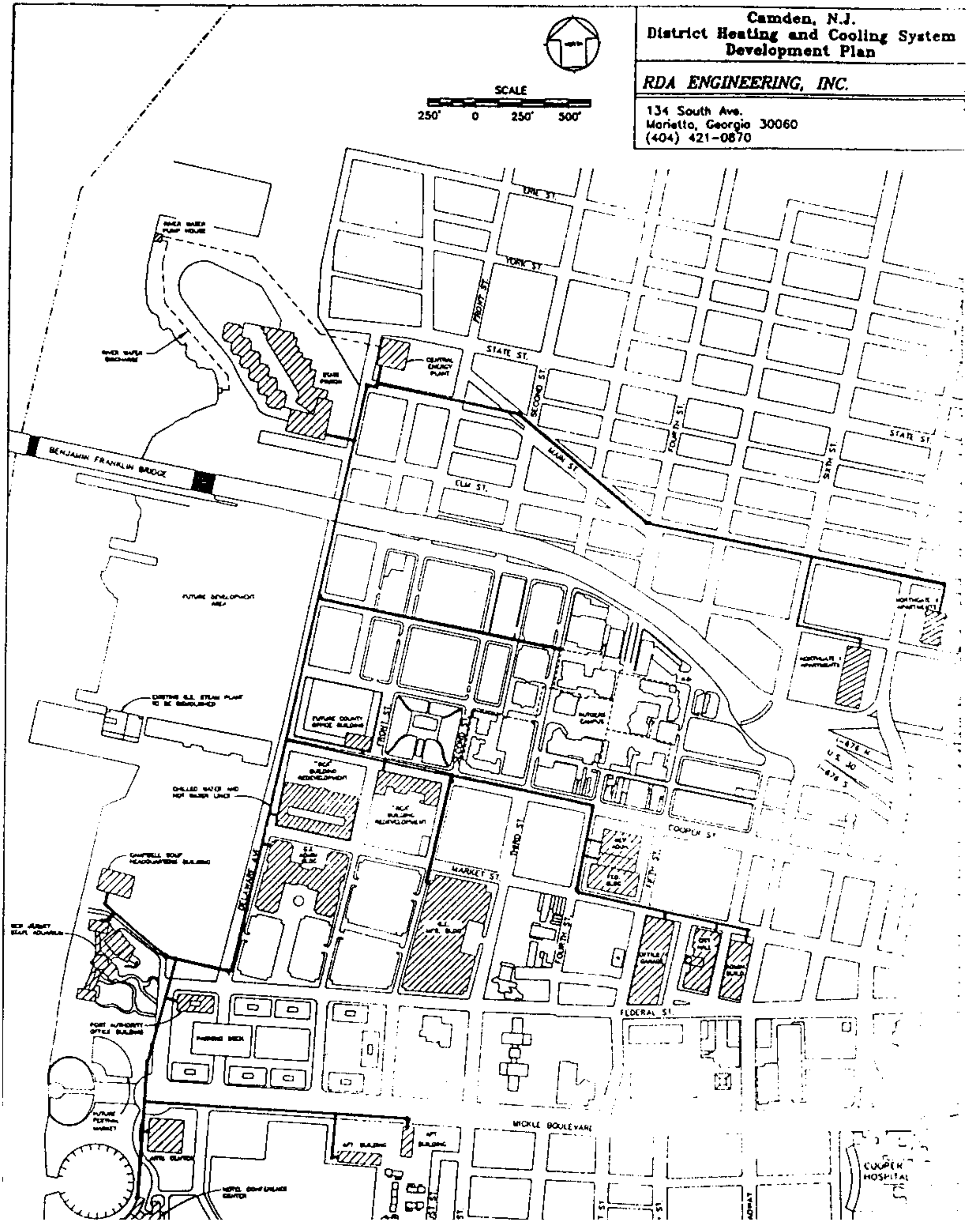
supporting district heating has been developed among community leaders, customers, and neighborhood groups so that the City's Department of Utilities feels comfortable taking the leading role in project development.

CAMDEN'S DISTRICT COOLING FUTURE

While district cooling's future in Camden is not certain, plans are currently underway to develop a district heating and cooling system to serve the waterfront development area, rehabilitated RCA buildings and several institutional customers such as Rutgers University, the State Prison, and local government buildings. The system developer will be the City's Department of Utilities.

Work efforts are now underway to configure piping systems and a central energy plant and to negotiate thermal energy supply from a local cogeneration developer. State or federal grants or no interest loans will be required for initial piping system development in order to insure infrastructure sized to serve future waterfront buildings. If all goes as planned, construction could start in 1993.

Figure No. 2 is a site plan showing the initial system customers and proposed location of the central energy plant. Both hot water and chilled water services will be supplied by the new system.



Camden, N.J.
District Heating and Cooling System
Development Plan
RDA ENGINEERING, INC.
134 South Ave.
Marietta, Georgia 30060
(404) 421-0870
SCALE
250' 0 250' 500'
ERIE ST.
YORK ST.
FRONT ST.
STATE ST.
SECOND ST.
FOURTH ST.
SIXTH ST.
MAIN ST.
ELM ST.
BENJAMIN FRANKLIN BRIDGE
CENTRAL ENERGY PLANT
FUTURE DEVELOPMENT AREA
FUTURE COUNTY OFFICE BUILDING
RUTGERS CAMPUS
CHILLED WATER AND HOT WATER LINES
CAMPBELL SOUP HEADQUARTERS BUILDING
DELAWARE AVE.
MARKET ST.
THIRD ST.
COOPER ST.
FIFTH ST.
I-676 N
U.S. 30
I-676 S
FEDERAL ST.
PARKING DECK
PORT AUTHORITY OFFICE BUILDING
FUTURE FESTIVAL MARKET
MICKLE BOULEVARD
APT. BUILDING
HOTEL CONFERENCE CENTER
COOPER HOSPITAL

7.5 Regional Workshop

Jamestown, New York

June, 1994

TEN YEARS OF EXPERIENCE OF DISTRICT HEAT SUPPLY FROM A RETROFITTED POWER PLANT

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Jamestown, New York

INTRODUCTION

This paper addresses the development and operation of the Jamestown District Heating System in the City of Jamestown, New York. The conception of the system through the initial feasibility studies is discussed, followed by the development of the system through phased implementation and the current status of operation. The planning aspects which contributed to the successful development of this system are highlighted and the customer savings are cited. Finally, problems encountered with the development and operation of the system and their solutions are examined.

The Jamestown District Heating (DH) concept was a result of a preliminary feasibility study, financed by the New York State Energy Research & Development Authority (NYSERDA) in October of 1981. The study examined the potential of a district heating (DH) system to economically supply the downtown area of Jamestown with thermal energy from the municipal electric plant. The results of the study were promising, indicating the technical and economic viability of the project. In light of the positive findings, a comprehensive second phase study was contracted in order to develop the necessary information for a final decision. The objectives of the second phase study included an engineering reference design as a basis for the financial analysis, a marketing program, a final design, the engineering bid and specifications, the basis for the financial instruments for project financing, and a project implementation plan. This study was financed by NYSERDA and the City of Jamestown. Based on the favorable results of the feasibility studies, the City of Jamestown committed to build a pilot system during the summer of 1984 and expand it to include selected buildings in the downtown core area during the following year.

SYSTEM DESCRIPTION

The Jamestown DH system consists of three major components: the cogeneration power plant, the transmission and distribution network, and the participating buildings or customers. Each component is addressed individually in the following subsections.

Cogeneration Power Plant

The Steel Street Power Station was selected as the central energy source for the Jamestown DH system. The power plant includes four coal fired boilers and two steam driven turbine-generator units (Units 5 & 6), both with General Electric non-reheat turbines. Unit 6 was selected for DH modification considering its larger heat output and relative ease of retrofit to cogeneration. This turbine is a 25,000 KW, 3,600 rpm, 15 stage single-flow condensing unit, designed to operate at 850 psig steam pressure, 900°F temperature, and 3.5 inches Hg condenser pressure; it has a rated throttle flow of 238,072 lbs/hr. Extraction steam for regenerative feedwater heating is taken from four extraction points. The turbine has one blanked-off extraction point at the 11^{th} stage. The feedwater heating cycle consists of four closed and one open feedwater heaters with makeup to the cycle through the condenser hotwell. Steam is extracted from the blanked-off 11^{th} stage turbine extraction for use in a new district heat exchanger for loads up to 7 MWt. Loads in excess of 7 MWt are served with additional steam from the auxiliary steam header and used in the existing auxiliary heat exchanger that is arranged in series with the new district heat exchanger (Figure 1).

During peak heat load operation, the return water temperature is 160°F with a DH water supply of 250°F. The DH water flow-rate during peak load conditions is 498,000 lbs/hr. The maximum extraction flow available from the turbine's 11^{th} stage provides heating for 379,000 lbs/hr of district circulating water to 210°F. At the maximum heat load conditions, 119,000 lbs/hr of DH water bypass the district and auxiliary heat exchangers. The 379,000 lbs/hr of 210°F effluent water from the district heat exchanger is passed through the auxiliary heat exchanger. This increases its temperature to above 250°F, so that when mixed with the 210°F, 119,000 lbs/hr bypassed water will produce a total flow rate of 498,000 lbs/hr at 250°F.

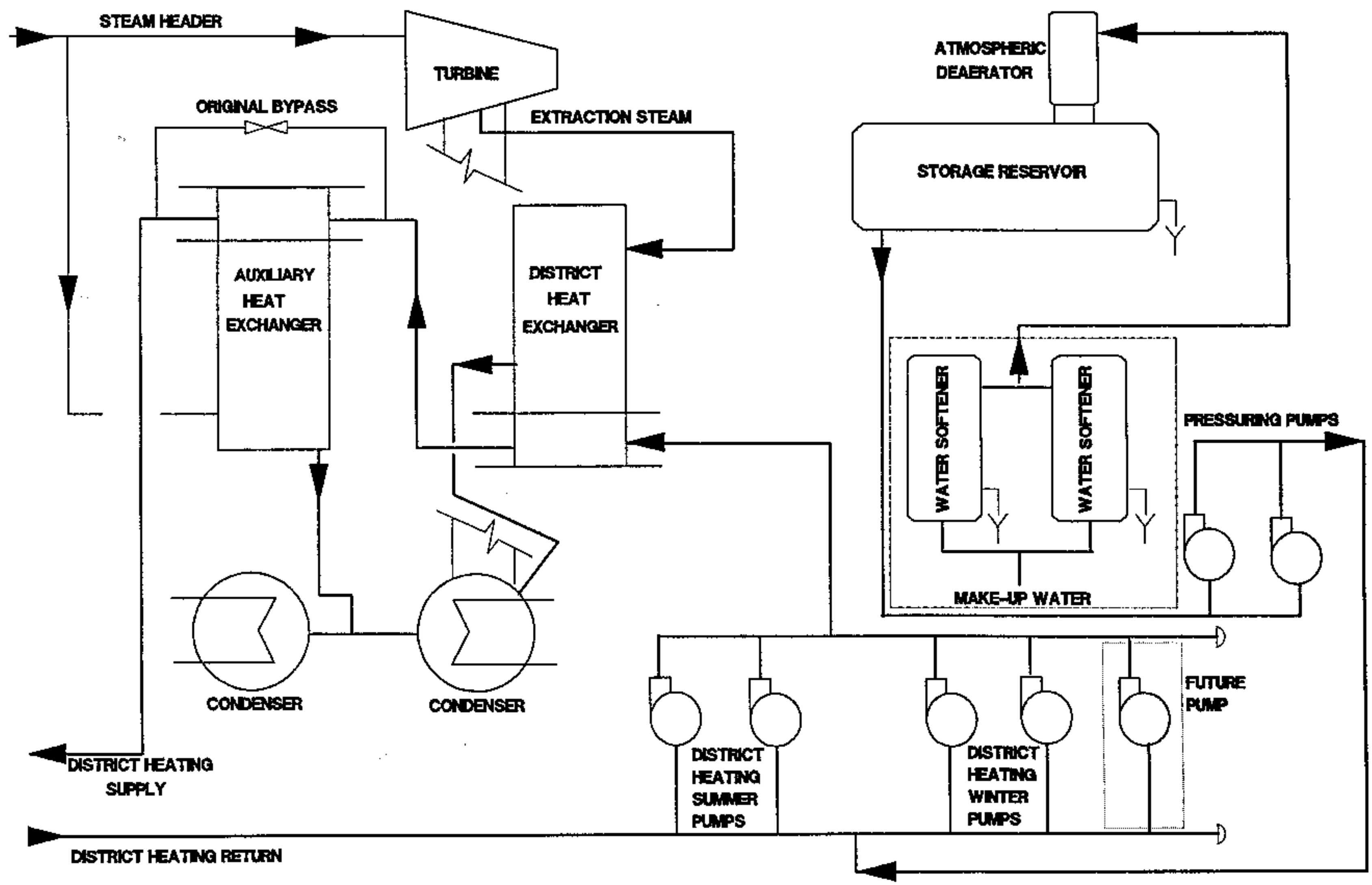
The district heat exchanger operates throughout the year, providing hot water for both space heating and domestic use. The auxiliary heat exchanger operates about one third of the year. The maximum operating pressure of the district heat exchanger is about 20 psia; the maximum operating pressure of the auxiliary heat exchanger is 60 psia with a maximum steam flow of 18,900 lbs/hr.

During a heat load range of 7 MWt or less, the auxiliary heat exchanger is out of service and the maximum extraction steam flow to the district heat exchanger is 23,813 lbs/hr at an extraction stage pressure of 21.8 psia. The reduction in electrical output from the Unit 6 turbine-generator

FIGURE 1

JAMESTOWN DISTRICT HEATING SYSTEM

COAL FIRED COGENERATION POWER PLANT



during DH operation is approximately 1.24 MWe. Modifications to the turbine are not required since the redistribution of extraction flows is minimal and all existing feedwater heaters remain in service without modification.

Transmission & Distribution Network

The transmission and distribution network transports DH water from the central plant to the customers and back. It is an underground two pipe closed system with a maximum operating pressure of 232 psi and with pumps sized for a total design discharge pressure of 140 psi. The piping is sized for a maximum velocity of 8 ft/s, based on the peak load supply and return temperatures of 250°F and 160°F.

The prefabricated conduit system consists of a thin wall carbon steel carrier pipe, polyurethane insulation, polyethylene casing, and a leak detection system. The leak detection system combines alarm and fault locator capabilities and is built into the conduit during manufacture to protect the system and facilitate service.

The DH piping is installed in shallow trenches requiring minimal excavation and no shoring. The conduits are laid directly in the trenches on a sand bed. There are at least 6 inches clearance between conduits and between each conduit and the adjacent trench wall. A homogeneous layer of stone-free sand is used to cover the conduits with a surface pavement on top.

Figure 2 presents the transmission and distribution network of the Jamestown DH system. The system development is described in a subsequent section, were the three phases of implementation are individually addressed.

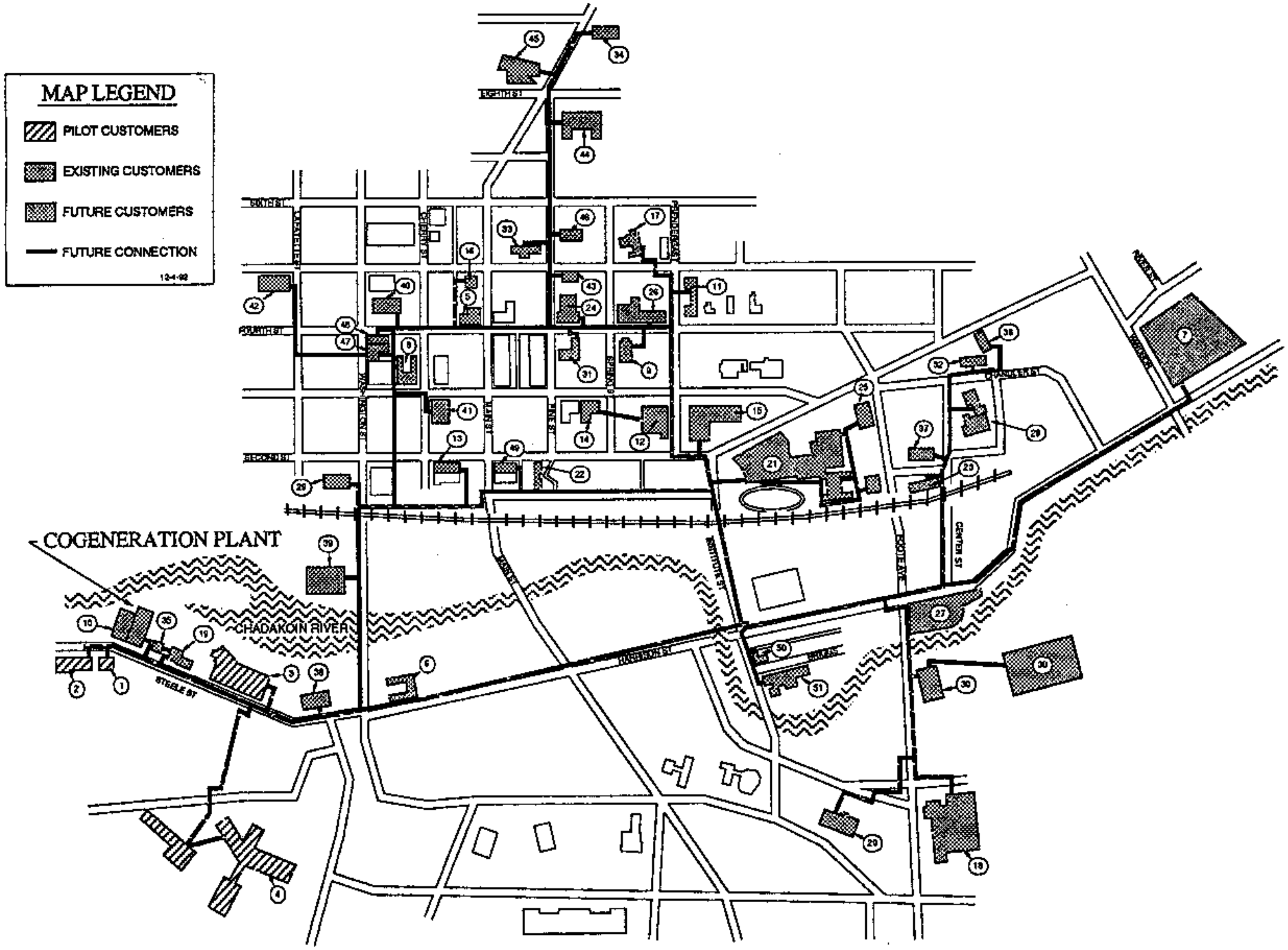
Buildings

The building conversions to DH depended largely on the existing individual heating systems. The design philosophy for the building retrofits is based on the following considerations:

* A plate-type heat exchanger is used in each building to transfer heat from the DH water supply to the building distribution system. This is necessitated by the high temperatures and

Figure 2

JAMESTOWN UNDERGROUND PIPING NETWORK



EXISTING CUSTOMERS

1. BPU GARAGE
2. DPW GARAGE
3. JAMESTOWN PLYWOOD
4. JONES HILL HOSPITAL
5. YWCA
6. NELSON LUMBER
7. MRC BEARING
8. HOTEL JAMESTOWN
9. BOARD OF EDUCATION
10. CARLSON GEN. PLANT
11. CONSISTORY
12. CITY HALL
13. POST JOURNAL
14. CIVIC CENTER
15. POST OFFICE
16. UNITED WAY
17. 1ST COVENANT CHURCH
18. WCA HOSPITAL
19. BPU MONITOR
20. BOYS CLUB
21. SENIOR HIGH SCHOOL
22. LITTLE THEATER
23. CRANE ST. HOUSING
24. YMCA
25. EPWORTH CHURCH
26. ALLTEL BUILDING
27. RIVERSIDE MALL
28. 1ST LUTHERN CHURCH
29. BPU SUBSTATION
30. CHAUTAUQUA HARDWARE
31. UNIGUARD
32. CHANDLER ST. APARTMENTS
33. BURGETT & ROBBINS
34. WILLOW APARTMENTS
35. COAL HANDLING FACILITY
36. IMMANUAL LUTHERAN CHURCH

FUTURE CUSTOMERS

37. LUTHERN TOWERS
38. EVANS BUILDING*
39. SONIC STAR
40. HOLIDAY INN*
41. COVENANT MANOR
42. JAMESTOWN HIGH RISE
43. WEINAUG & BENSON
44. LOVE SCHOOL
45. PAIGE BUILDING
46. MEDICAL ARTS BUILDING
47. VIKING TEMPLE
48. CREDIT BUREAU*
49. FENTON BUILDING*
50. JNK
51. ARTONE MANUFACTURING CO.

* Service Connections Exist

pressures in the DH distribution network.

* The DH water supply temperature varies according to outdoor temperature, from a maximum of 250°F, on the design day (3°F outdoor temperature), to approximately 170°F during the summer months. Therefore, the building heating system distribution temperature must also be reset from the outdoor temperature.

* Building systems operating temperatures were selected to optimize the size of system components, producing maximum temperature differentials between supply and return.

Conversion of two-pipe steam heating systems to DH was the most prevalent building retrofit in the City of Jamestown. A plate & frame heat exchanger replaced the existing boiler as a heat source. Existing steam and condensate piping, wherever possible, were used to form a closed water loop, with the installation of circulating pumps, expansion tank, and air removal system. All steam traps were removed and air vents were installed at system high points.

Conversion of a gas-fired hot air heating systems involve the installation of a new hot water heating coil in the return air duct, along with an associated plate-type heat exchanger and closed loop hot water circulating system. In instances where a significant amount of outside air was used, a pre-heater hot water coil was installed in the outdoor air supply duct.

Existing hot water heating systems were the simplest and most cost effective to retrofit. In most cases, it merely required the installation of a plate-type heat exchanger.

The conversion and interconnection of all DH customers was timely and economical. This is mainly attributed to the extensive bid packages, which introduced in detail the various concepts of individual heating systems conversion to DH, and to the training and consultations furnished by the consulting engineer.

SYSTEM DEVELOPMENT

The successful development of Jamestown DH System is a result of the strong support from the City, the BPU, and NYSERDA, and the technical expertise and well orchestrated effort of the consulting engineer. The overall cooperation and strong community support for the project enabled local officials to enthusiastically promote the system, to obtain financing, and to meet an ambitious construction schedule.

Parallel development of the three main system components, power plant, piping network, building retrofits, was necessitated by the inflexible schedule. Work had to be completed by the end of the summer in order for the system to be operable during the start of the heating season.

Phased Implementation Philosophy

The objective of phased implementation is to develop the system in stages, spreading the capital expenditures in incremental investments over the development period and allowing the system to generate revenues to offset the capital investment. DH in Jamestown is developed in three phases, starting with a pilot system in the first phase, a core system in the second phase, and planned annual growth in the third phase. A pilot project initiated the effort in 1984, which eventually was expanded to a core system in 1985-1986, and has been growing ever since.

The purpose of the pilot project was to impart valuable experience in construction and operation to the local DH officials prior to embarking in a larger venture. The pilot system was also used as a marketing tool to attract skeptic customers. The authorization for the pilot system development was given in June 1984, with actual construction commencing in August and operation in November of the same year. The pilot system served four buildings:

* Jones Hill Hospital
* Jamestown Plywood Corporation
* Department of Public Works (DPW) Garage
* Board of Public Utilities (BPU) Garage

The second phase of DH development in the City of Jamestown involved the retrofit and interconnection of 15 additional buildings the next two years (1985-86), after an aggressive marketing campaign. An extensive transmission system was installed, as part of the second phase development, providing the foundation for future growth. The third phase is ongoing and involves the planned annual growth of the system. This phase capitalizes on the existing network and merely requires the retrofit and interconnection of new customers, along this transmission line.

Marketing

The installation of the pilot system in 1984 created a public awareness which, coupled with the marketing activities, replaced the initial skepticism with enthusiasm for DH and its benefits. The marketing aspects of DH development in the City of Jamestown involved the combined efforts from the Mayor's Office, the Board of Public Utilities (BPU), other city officials, and the consulting engineer.

Numerous public and private meetings were scheduled with prospective core customers in order to educate them and discuss the advantages of DH for their buildings. A marketing campaign through the media, newspapers/ magazines, radio, and television was used to establish a public consciousness and acceptance, offering evidence through the operation of the pilot system. Brochures were prepared to complement this effort. The marketing venture targeted a diverse customer base, including schools, churches, hotels, hospitals, and retail, office, residential and industrial customers. An ad hoc committee consisting of representatives from:

* major customers and contractors,
* the Manufacturers' Association,
* the Department of Economic Development,
* the Department of Industrial Development,
* and the Department of Public Works,

was formed, under the sponsorship of the Mayor's Office and the BPU to develop a complete community awareness and involvement.

As part of this coordinated effort, the consulting engineer examined prospective customers and presented them with economic packages indicating conventional heating costs, DH costs, and anticipated savings. The benefits and advantages of DH were reiterated. Once a potential customer expressed interest in participating in DH, the consulting engineer was responsible for the conversion of their heating system to DH.

Ownership

Centralized energy projects have exhibited an entire spectrum of ownership structures, which can be classified as either private or municipal. The threshold alternative considered for the Jamestown DH project was the selection of the most appropriate classification. The most important consideration for this selection were the constraints imposed by New York State legislation.

In New York State, constraints related to the operation of a centralized energy system are imposed by the public utility regulatory framework and the franchise authority of the local municipality. The degree of such impediments varies substantially with the form of ownership.

Since the DH system sells energy to consumers, it is subject to the jurisdiction of the State Public Utility Commission regarding rates, system accounts, extension of services, siting and construction of facilities, and sale or lease of properties. In addition, such systems must rely upon the municipality to grant franchises for the use of public streets and sidewalks.

The municipal alternative was selected based on the minimal impact by regulatory constraints. The City of Jamestown presented a distinct advantage over most other localities which have instituted DH systems, because it already operates a municipal electric plant. This electric utility is experienced in dealing with the regulatory environment and is attuned to the City's needs and procedures. The existing structure of the Jamestown Board of Public Utilities (BPU) presented a unique opportunity for the City to institute a DH system which is fully responsive to the interest of the City, with only limited additional procedural, administrative, and managerial costs. The Jamestown BPU has existing authority to use public right-of-ways. Other important factors in the selection of municipal ownership include the federal and state tax-exempt status, and the customer acceptance and trust of municipalities over profit-oriented, private entities.

SYSTEM ECONOMICS

The positive economic analysis results served as the cornerstone for the development of the

Jamestown DH System. The economic analysis was performed from the viewpoint of municipal ownership, utilizing its distinct advantages. The analysis determined the annual carrying charges for the system and the unit cost of district heat. The analysis employed the required revenue approach to determine the necessary charges for DH sales. The method used was to develop the total system costs and compare these costs with the total quantity of heat sold to determine the minimum required charge for DH.

The operating expenses for the DH system were comprised of replacement electricity costs, pumping costs, O&M personnel, O&M materials, and steam costs. The replacement electricity cost is charged against the DH system to compensate for the reduction in electrical output caused by the DH steam extraction requirements.

Rates

The initial charge for DH was set at $7.00/MMBtu. This rate is a direct result of an economic analysis, using a detailed cash flow. It allows the utility to pay back the debt and the customers to experience energy savings. A rate of $6.00/MMBtu was instituted for large users in 1990. Large user status is granted when the monthly consumption exceeds 300 MMBtu's. The two rates remained constant until 1991, when a 10% increase was approved by the Board of Public Utilities. The current rates are $7.70/MMBtu and $6.60/MMBtu for large users. A peak demand rate is currently under consideration, with an incremental use discount.

Financing

In the context of municipal ownership, the normal source of funding for a DH project is obtained through the issuance of long-term revenue or general obligation bonds. A long-term municipal bond offers a fixed interest rate over the life of the project. The volatility and relatively high levels of interest rates on long-term obligations, at the time, led to the development of a broader spectrum of tax exempt alternatives, including short-term and floating rate longer term instruments. Short-term tax exempt alternatives afforded the opportunity to take advantage of the substantially lower interest rates during the construction period. However, short-term bonds were available if long-term bonds were intended to be the ultimate debt. A short-term debt is considered to be any debt with a maturity of less than one year.

The Phase I development of the Jamestown DH System, involving the institution of a pilot system, was financed with short-term bonds. The later phases were financed with long-term bonds, including the refinancing of the first phase.

SYSTEM BENEFITS

The benefits derived from the implementation of a DH system are multifaceted. DH benefits include environmental advantages, Demand-Side Management application, customer savings, and potential for urban economic revitalization. Customer savings and environmental advantages are among the most important by-products of DH development in Jamestown, with the DSM application become increasingly recognized. An advantage specific to the Jamestown DH system design is the elimination of the chemical water treatment without corrosion consequences.

Customer Savings

The reduction and stabilization of natural gas rates in the recent years have contributed to a lower customer savings rate, which is still above 20%. During the period of 1984 through 1993 the DH customers have experienced a cumulative savings of $1.8 million from participating in this DH system instead of operating their individual equipment. The savings rate increases with any increase in the price of fuel. Customer savings are expected to rise in the future as the system grows with minimal capital investment.

Environmental

District heating is an energy conservation measure noted for increased thermal efficiency, reflected in the energy savings of connected customers. Higher thermal efficiency corresponds to more useful energy output per given quantity of fuel input. In addition, centralization of load eliminates the sharp spikes in demand of individual buildings. These load spikes result in the oversizing of equipment, which are selected for peak conditions and fail to provide optimum performance at other conditions. Load leveling permits the plant to operate at reduced peak and at longer sustained intervals, which contribute to enhanced energy utilization. All this translates to lower emissions and consequently reduced environmental pollution. Boilers used by individual customers cycle on and off producing a loss in efficiency, partially associated with the incomplete combustion of fuel. The continuous and efficient operation of a central plant, especially during a cogenerative mode (waste heat recovery), reduces the carbon monoxide and hydrocarbon emissions which are characteristics of incomplete combustion.

Demand-Side Management Application

The substantial increase of demand for electrical power over the past years, along with the enormous costs associated with the addition of new capacity have led to the emergence of new developments in the area of energy efficiency. Utilities nation-wide have developed Demand-Side Management (DSM) programs to address the disparity of peak loads versus the base loads, as well as their seasonal variation. In general, these programs target demand reduction by removing inefficiencies, a more economically viable option than the installation of new capacity.

District heating offers potential for DSM application by replacing electrical heating systems. Electrical systems are converted to hot water and interconnected with the DH system. This conversion to district service eliminates the electrical demand for heating. This application of DH is significant for the City of Jamestown, considering the winter peaking characteristics of the electrical utility.

SYSTEM DEVELOPMENT & OPERATING PROBLEMS

The development of most energy projects, especially district, which involve exposure to city streets is usually accompanied by unanticipated problems or obstacles. In general, the greater the size and complexity of the system and the exposure to interferences in city streets, the higher the probability of unexpected impediments. The Jamestown DH System development was a success in this respect considering the minor inhibitors encountered. The successful development of this project is mainly attributed to the wide support and close cooperation of all participants and the experience and careful planning by the consulting engineer.

The significant obstacles in this development are individually addressed below. The installation of thin-walled piping was a problem which was quickly resolved, while the performance of the original plate & frame heat exchangers and BTU meters are currently being addressed.

Piping Installation

The installation of the transmission and distribution network started with the problem that the union plumbers were not familiar with the welding of thin-walled piping. Anticipating the future need for this process, the city trained their own construction personnel in the procedure of welding thin-walled piping. This enabled the efficient installation of the pilot system, while maintaining the expertise for the expansion that followed and the potential growth of the system.

Plate & Frame Heat Exchangers

The original design incorporated imported plate & frame heat exchangers for commercial applications. These heat exchangers received positive reviews from international users. The decision to install plate & frame instead of shell & tube heat exchangers was based on the better approach temperature of the former (2°F versus 5°F), cost, and space requirements. Plate & frame heat exchangers are less expensive than their shell & tube counterparts and require less space. They can fit existing mechanical rooms without modifications or removal of retired equipment.

After approximately five years of operation, these heat exchangers developed leaks through their gaskets. Repairs appear costly and ineffective for the long term. New, domestic plate & frame heat exchangers for industrial application are used to replace the original heat exchangers that develop leaks. The new heat exchangers have a sturdier design, using thicker plates and specially treated gaskets, which retain their elastic properties.
A shell & coil heat exchanger, recently introduced in the market at a competitive price and with the same approach temperature as the plate & frame, is currently under consideration.

Metering

Metering of heat energy is facilitated through the use of BTU meters. BTU meters measure accurately the flow and temperature difference of supply and return DH water and compute the amount of heat extracted by each consumer. The use of 'turbine meters' (turbine actually intruding in the water path, measuring flow) presented maintenance problems, as the turbines and bearings wore out. This wear is attributed to the wide flow range of DH water, which often exceeds or falls below the operating meter range. Damage to turbine blades are not always apparent and as a result produce a false reading in favor of the customer.

As long as the electronic integrator functions properly, it has been more cost effective to replace the turbine blades and bearing, rather than the entire unit. An alternative BTU meter, fluidistor type, is under examination and testing, and considered a potential replacement for the turbine meter.

The fluidistor type meter uses an oscillating ball in lieu of a turbine with a bearing. This movement of the ball within each chamber also induces a self cleaning action, which lacks from its turbine counterpart.

CONCLUSION

The successful development of district heating in the City of Jamestown, New York, is the result of a well coordinated effort, starting with the system's conception to its operation and growth. The promising findings of the initial feasibility study were pursued further in a second phase detailed study, used to make the final decision. The system was implemented in stages, starting with a pilot project which was used as a marketing vehicle, demonstrating the system's benefits, savings and reliability. A coordinated effort among the Mayor's Office, the BPU, and the consulting engineer, produced an effective marketing campaign. Meetings and advertising created a public awareness which eventually led to an extensive community participation.

The consulting engineer met with the perspective customers, providing individualized attention and marketing leverage. They produced comprehensive bid and specification packages and trained the contractors in the retrofit process for the various heating systems. The design and planning of the consulting engineer produced a cost effective development, with phenomenally low installation and retrofit costs.

The system ownership and financing capitalized on the advantages offered by the municipal avenue. The BPU promotes and operates the Jamestown District Heating System. This enables the City of Jamestown to control the major sources of energy: electricity and heating. The municipal control of these energy sources is used as an economic development tool by the city to attract new business.

The future of DH is Jamestown appears very attractive considering the development of a system with twice the capacity of the present load. The present 13 MWt peak load can be expanded to match the available 26 MWt capacity with minimal capital investment. Any system growth beyond the existing customer base is expected to enhance the economic operation of the system.